UNITED REPUBLIC OF TANZANIA

MINISTRY OF ENERGY

TANZANIA ELECTRIC SUPPLY COMPANY LIMITED (TANESCO)

RUFIJI HYDROPOWER PROJECT



METHOD STATEMENT-DIVERSION TUNNEL CONSTRUCTION

October-2019

The ARAB CONTRACTORS and
ELSEWEDY ELECTRIC S.A.E.
Joint Venture (ACEE JV)

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RUFIJI HYDROPOWER PROJECT (2115 MW)

TANZANIA

DIVERSION TUNNEL CONSTRUCTION METHOD STATEMENT

Project Name: **Rufiji Hydropower Project (2115 MW), Tanzania**
Employer: **Tanzania Electric Supply Company Limited (TANESCO)**
Employer's Consultant: **Tanroads Engineering Consultant Unit (TECU)**
Contractor: **The Arab Contractors & Elsewedy Electric JV**
Sub-Contractor: **Sino Hydro Corporation Limited**

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GENERAL

Diversion standard for diversion tunnel during construction period is for a 5-year return period of the full year, corresponding to a discharge of 6170m^3/s. Corresponding to the inlet water level 85.8 m of diversion tunnel, the outlet water level 82.1m of diversion tunnel. During the construction period of plugging of the diversion tunnel, the temporary water retaining standard for its inlet is for the 10-year return period in flood season, corresponding to a discharge of 8363m3/s. The temporary water retaining standard for its outlet is for the 5-year return period flood of flood season.

The tunnel control structure is positioned upstream of the tunnel inlet portal with Invert Level: 68.50 m. In middle part of the Diversion Tunnel will be excavated an Adit Tunnel of size: 8.4 m*7.2 m with a 147.67 m length & Portal Elevation EL 83.0 m that intersection the DT at CH 0+330.6 m to expedite the rate of Tunnel Excavation Progress by increasing the two excavation faces.

The diversion tunnel is located on the left bank of the dam, with a total length of 703.76m, an inlet invert elevation is EL68.5m and an outlet elevation of EL. 65.0m. The gradient the Diversion Tunnel is 0.497 %. Mainly for diversion tunnel rock type is of class III, part section is class IV. The diversion tunnel is composed of inlet Gradient Section + Body Section + Plugging Section. The size of the tunnel lining is 12m * 17m (W*H), and the underground excavation volume is approximately 247,852 m^3.

The Excavated material, some of will be used to raise the level of T6 road and rest of remaining material will be disposed in the designated Disposal Area 25 as shown in the Construction General Layout (Attachment # 10).

The open cut excavation height of tunnel inlet is 66.5 form the EL132.0 m – EL 65.5 m (Bottom Invert excavation level). The open cut excavation height of tunnel outlet is 80.8 m (form EL. 145m – EL 64.2 m), while the bottom of the lined diversion tunnel is EL. 65.0 m and top of the portal arch is EL. 82.0m. The total open excavation volume of inlet is approximately 81,959 m^3, and the total excavation volume of outlet is approximately 175,104 m^3.

The diversion tunnel is composed of inlet Gradient Section + Body Section + Plugging Section. The size of the Diversion Tunnel after Reinforced Concrete Lining (With CY 20 Concrete Mix Design) is 12m * 17m (W*H). The thickness of the diversion tunnel lining concrete is 800mm~1000mm ~2500mm. And the max thickness of the lining concrete is 3000mm on plug section. The total volume of diversion tunnel concrete is about 62,732m^3.

Calculations on Discharge Parameters for Diversion Tunnel;

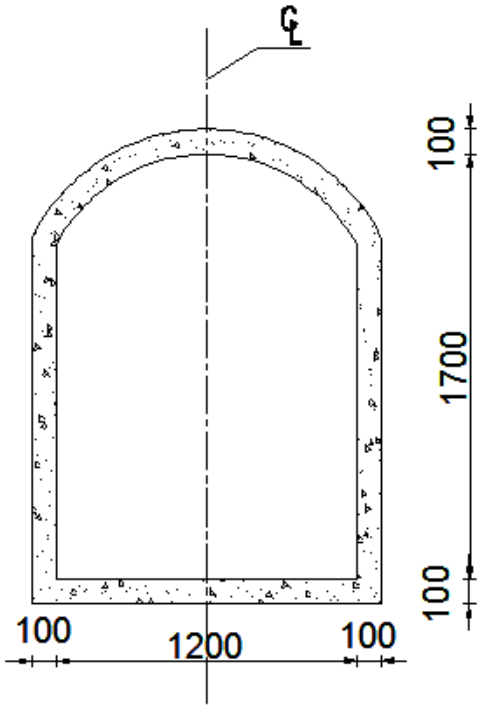
1. Dry Season Discharge, Q20 = 1865.0 m3/sec.
2. Passing Through Discharge, Q @El 90.0 masl (WL at US of Coffer Dam) = 1870.0 m3/sec
3. Passing Through Discharge, Q @EL 90.0 masl = 1870.0 m^3/sec > Dry Season Q20 = 1865.0 m^3/sec
4. Hence the DT X-section of size: W*H = 12.o m*17.0 m is Safe, Economic & Appropriate.
5. The Max. Retaining/Passing Through Discharge Q @ EL 91.5 m = 1999.0 m3/sec.
6. Cross Sectional Area of DT = 189.0 m2 & The Velocity = 9.7 – 12.4 m/sec. (Normal-Pressure Flow).

Note: Above elaborated data are from the "Basic Design Report", Volume III: Civil Works, Rev.; B, 3.2.5 Diversion Building design, 3.2.5.1 Arrangement of diversion Tunnel & Table 3.2.5 - 2 Joint Discharge Curve of DT & U/S Cofferdam.

1.1 SCOPE OF WORK

The works will comprise of diversion tunnel including adit, inlet and outlet portal excavation upstream of the main dam area and underground excavation by drilling and blasting method, mucking of excavated material and rock supporting according to approved Design Drawing and Technical Specification.

Table: The Specifications of Diversion Tunnel are given in Table below:

Items	Specification	Typical Cross section
Type	Reinforced Concrete Lined Tunnel (CY20)	
Size of lined Tunnel	12 m x 17 m	
Length	703.76 m	
Slope	0.497 %	

1.2 ORGANIZATION AND RESPONSIBILITIES

1.2.1 EPC Contractor-JV-ACEE

1.2.1.1 Civil Site Manager:

1. Overall responsibility for the execution of construction work

1.2.1.2 QA/QC Manager:

1. Construction Supervision and Monitoring of all Civil Works related to QA/QC procedures.
2. Inspection and Testing: Shotcrete Mix Design, Concrete Mix Design,
3. Inspection and calibration of all lab and in situ testing equipment's and machines like a batching plant scale.

4. Preparation of inspection, test record and test reports.
5. Coordination with the Resident Engineer on all QA/QC matters
6. Ensure project civil programs meet contract and Company's ISO requirements.
7. Ensure adequate Civil QC supervision at project level.
8. Ensure project Civil QC is being performed and documented as per contract and approved Civil QC program.
9. Gain and maintain the confidence of the Company Project Client management in matters related to Company quality and customer satisfaction.
10. Respond to quality technical queries/clarifications that might be raised during project executing.
11. Provide timely and needed support to QC team, resolve any conflicts with other project Discipline.
12. Control all civil nonconformance report, and undertake remedial action.
13. Monitor the implementation of the approved site QC plan.
14. Monitor and control the status of punch list and exception lists relevant to quality dossiers

1.2.1.3 Geological/Geotechnical Engineer:

1. Conduct face mapping at each station and analyze that data by using standardized Geotechnical Classification Method Rock Mass Rating (RMR) or Q-System, in order to define the rock mass grade.
2. Monitoring the reinforcement (systematic & random rock bolt, fore poling, pipe roof etc.,) and direction of rock dowels to be installed at each excavated face and confirm it after installation. Also decide the type (H- beam and Lattice girder) and position of support to be installed and confirm it after installation.
3. Check the results of rock bolt pulling test and Shotcrete test by QA/QC according to specifications.
4. Preparation and record the Geological data for each station. Data includes Checklist, Face and wall Mapping, Blasting Pattern and Blasting Results of each station.
5. Investigating the ground water status at each face as well as the geo-mechanical conditions of the rock mass through probe holes.
6. Monitoring the weak zones (fault, fracture zone, shear zone etc.,), decide the most suitable excavating method by considering the geological features such as geological rock condition, upper ground level circumstances.
7. Undertake investigations regarding rock falling, collapse/failure at weak zones and take appropriate measurements to prevent the rock falling. Reducing the over break during the excavation as small as possible.
8. Coordination with Resident Engineer on all geological matter

1.2.1.4 Site Engineer:

1. Preparation of work procedures
2. Document and drawing control of site preparation

3. Coordination with QA/QC department regarding inspection and testing
4. Check and review of progress schedule.

1.2.1.5 HSE Manager:

1. Site supervision for safety and environment control.
2. Practical responsibility for the implementation of HSE program.

1.2.2 Sub-Contractor-SHC

1.2.2.1 Project Manager:

1. Overall responsibility for the execution of construction work

1.2.2.2 QA/QC Manager:

1. Inspection and Testing: Shotcrete Mix Design, Concrete Mix Design
2. Inspection, monitoring, and Testing; All instrumentations installed in the Project and follow up all the results and reports.
3. Inspection ad calibration of all lab and in situ testing equipment's and machines
4. Preparation of inspection, test record and test reports
5. Coordination with the Resident Engineer on all QA/QC matters

1.2.2.3 Tunnel/Site Engineer:

1. Practical responsibility for implementation of work execution
2. Control of manpower and equipment
3. Coordination with QA/QC department regarding inspection and testing
4. Topography coordination
5. Ensure following of constructive methodology and procedures works.

1.2.2.4 Geological/Geotechnical Engineer:

1. Conduct face mapping at each station and analyze that data by using standardized Classification Method Rock Mass Rating (RMR) or Q-System in order to define the Rock Mass Grade.
2. Decide the reinforcement (systematic & random rock bolt, fore poling, pipe roof etc.,) and direction of rock bolts to be installed at each excavated face and confirm it after installation. Also decide the type (H beam and Lattice girder) and position of support to be installed and confirm it after installation.
3. Check the results of rock bolt pulling test and Shotcrete test by QA/QC according to specifications.
4. Preparation and record the Geological data for each station. Data includes Checklist, Face and wall Mapping, Blasting Pattern and Blasting Results of each station.

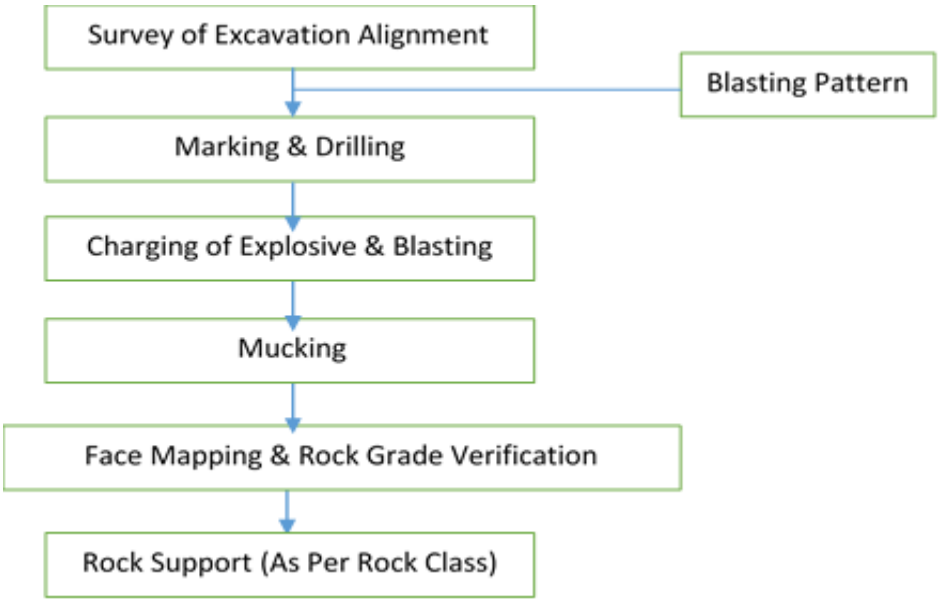
5. Monitoring the weak zones (fault, fracture zone, shear zone etc.,), decide the most suitable excavating method by considering the geological features such as geological rock condition, upper ground level circumstances.
6. Undertake investigations regarding rock falling, collapse/failure at weak zones and take appropriate measurements to prevent the rock falling. Reducing the over break during the excavation as small as possible.
7. Coordination with Contractor's representative on all geological matter

1.3 MANPOWER & RESOURCES *(Peak working intensity)*

No.	Description	Requirement	Arrived (y/m/d)
1	**Manpower**		
1.1	Engineer	15	2019/06/10
1.2	Forman	20	2019/06/10
1.3	Driver	76	2019/06/12
1.4	Operator	66	2019/06/12
1.5	Skilled Labor	80	2019/06/10
1.6	Unskilled Labor	200	2019/06/12
2	**Equipment's and Plants**		
2.1	Bulldozer 220 HP	1	2019/06/10
2.2	Bulldozer 320 HP	1	2019/06/10
2.3	Side Loader 3 m3	1	2019/06/10
		2	2019/09/15
2.4	Excavator 1.2 m3	1	2019/06/10
2.5	Excavator 2.1 m3	2	2019/06/10
		2	2019/11/15
2.6	Jack Hammer	1	2019/06/10
2.7	Dump Truck 20 ton	6	2019/06/10
		22	2019/11/15
2.8	Hydraulic Drilling Machine T35	3	2019/06/10
2.9	Hydraulic Drilling Machine 100 B	4	2019/06/10
2.10	Pneumatic Drilling Machine YT28	20	2019/06/10
		60	2019/08/15
2.11	Grouting Pump	2	2019/08/25
2.12	Motor Mixer 250L	4	2019/08/25
2.13	Grouting Recorder	1	2019/08/25
2.14	Shotcrete machine 8 m3/h	3	2019/06/10
2.16	Mixer Truck 8 m3	8	2019/08/25
2.17	Motor crane 25 ton	1	2019/06/10
2.18	Welding Machine 400A	4	2019/06/10
2.19	Air Compressor for drilling 21 m3 / min	3	2019/06/10
		2	2019/08/15
2.20	Concrete Mixer 350 L	1	2019/06/10
2.21	Air Compressor for drilling 40 m3 / min	3	2019/08/15
2.22	Ventilation Fan 2*75kw	4	2019/08/15
2.23	Generator 550kva	4	2019/06/10
2.24	Temporary concrete mixing station	1	2019/6/30
2.25	Transformer 1000kva	3	2019/09/10
2.26	Isolation cubicle 2000A	3	2019/09/10
2.27	Concrete pump $60m^3/h$	4	2019/12/01
2.28	Steel mould trolley 12m	1	2019/12/30
2.29	Steel mould trolley 6m	2	2019/12/01
2.30	Vibrator 50mm	40	2019/12/01
2.31	Plat vibrator	4	2019/12/01

No.	Description	Requirement	Arrived (y/m/d)
2.32	Crushing station	1	2019/08/01
2.33	Bathing station 60m3/h	2	2019/10/01
2.34	Steel cutting shear	1	2019/08/01
2.35	Steel bender	1	2019/08/01
2.36	Die head threading machine	1	2019/09/01
2.37	Saw for woodwork	1	2019/09/01

1.4 FLOW DIAGRAM



1.5 CONSTRUCTION SCHEDULE

Construction Schedule of Diversion Tunnel is provided in Attachment # 09.

1.6 SITE TEMPORARY FACILITY PLAN

Site mobilization includes following temporary facilities.

1.6.1 Power Supply:

The 400V 50Hz 3 phase's power system will be supplied to the portals and adit of diversion tunnel base on the project power supply plan, the standby diesel generators should be considered.

Location	33kv Transformer (1000kva)	Stand by Diesel Generator (550kva)
Inlet of Diversion Tunnel	1	1
Outlet of Diversion tunnel	1	1
Adit Tunnel	1	1
Total	3	3

1.6.2 Water Supply:

The water supply for construction is mainly directly extracted from the river by the water pump. 3 Nos. 10m^3 water tanks are set above the portals and adit of the diversion tunnel.

Location	Water Tank	Water Pump		Main Pipe DN90	Sub Pipe DN25
	m^3	Lift (m)	Power (KW)	m	m
Inlet of Diversion Tunnel	10	30	5.5	60	50
Outlet of Diversion Tunnel	10	30	5.5	70	50
Adit tunnel	10	30	5.5	400	100
Total	30			530	200

1.6.3 Compressed Air:

There are three 21 m^3 air compressors at the inlet and three at the outlet of diversion tunnel, three 40 m^3 air compressors will be installed at the portal of adit tunnel in construction peak time. These air compressors will be used to supply compressed air for YT28 pneumatic drill machines and shotcrete and etc.

Location	Capacity (m^3/min)	Quantity (peak)	Main Pipe to Tunnel	Sub pipe
Inlet of Diversion Tunnel	21	3	DN160/60m	DN50/50m
Outlet of Diversion Tunnel	21	3	DN160/70m	DN50/50m
Adit Tunnel	40	3	DN160/400m	DN50/100m
Total		9	DN160/530m	DN50/200m

1.6.4 Lighting Management Plan:

- Lighting shall be installed on the work site and paths surrounding in order to remove any risk factors during work.
- Tunnel lighting will be installed at 15.0 m intervals. Illumination shall not be less than 10 Lux. While working on tunnel face, light intensity will be maintained 160 Lux with the usage of movable lights.
- A stock of spare lights bulbs shall be maintained to allow for prompt replacement as needed. Emergency lights shall be made available.

1.6.5 Tunnel Drainage and Control of Ground Water:

- The design of provisional and permanent drainage system and the control systems required for ground water begins during the geotechnical exploration phases with an assessment of the potential of sources and volumes of water expected during the construction.
- The type of provisional and permanent drainage system required will depend upon the type of tunnel and site ground water conditions. Water occurring in diversion tunnel during

construction must be disposed of because it is a nuisance to workers and may make the placement of linings difficult or cause early weakening of the linings.

- The excavation sequence should be such that drainage of the sections to be excavated is accomplished before excavation. Thus, a pilot drift near the invert in a wet environment is more effective. It is an excellent practice to carry a drill hole in advance of the working face. The drill hole has an additional advantage of revealing rock conditions more clearly than defined by initial investigation but according to supplementary investigation the condition of ground water is clear now & situation has been considered by the contractor.
- The drainage system required in a tunnel will depend on the type of tunnel, its depth and ground water conditions.
- Gravity flow method will be used in Diversion Tunnel Excavation during the downstream heading. Whereas heading from the intake side may require pump and sump.

1.6.6 Ventilation Management Plan:

- For a safe and clean working environment, the tunnel must be adequately ventilated in order to remove gas, dust and exhaust gases from internal combustion engines from inside of tunnel.
- Water shall be used to minimize dust.
- The tunnel shall be use a ventilation duct.
- To meet air quality requirement, ventilation fan and/or exhaust fan will be installed.

Ventilation Calculation:

During drill:

25person*4m^3/min*1.2=100m^3/min

During Mucking:

(162kw (Loader) + 215kw (Dump truck) *2*0.3) *2.5m3/kw+4*4m3/min = 743 m^3/min

Maximum demand volume is 743 m^3/min

The maximum supply distance is about 200m with the leakage rate is 200 m * (1%/100m) = 2%.

The maximum output volume = 743 / (1-2%) = 758m^3/min

Machine model selection:2*37kw axial flow fan (810m^3/min)

Table: Ventilation Fan

Description	Intake Side		Outlet Side		From Adit Towards Intake		From Adit Towards Outlet	
	Nos.	Capacity	Nos.	Capacity	Nos.	Capacity	Nos.	Capacity
Ventilation Fan	1	75 Kw	1	75 Kw	1	75 Kw	1	75 Kw

1.6.7 Access Exit Road Management:

The road surface shall be maintained and repaired for safe passage of equipments and vehicles. Installation of safety sign boards if required. T5 and T6 temporary roads will be used for diversion tunnel excavation and concrete work. The excavated materials will be dumped to the spoil areas.

1.7 EXECUTION PROCEDURE

1.7.1 Execution Plan:

The Diversion Tunnel is critical path in this project, so Adit tunnel at the middle part area will be constructed to reduce the working period. Team A will work from the intake part, Team B & C will work from the middle part in both direction and Team D will work from the outlet part.

1.7.2 Open Excavation of Tunnel Entrance:

1.7.2.1 Construction Surveying

According to the requirements for different terrains, landforms and accuracy, the proper equipment and different sampling methods shall be selected for construction surveying, with all the sampling work conducted under the engineer.

1.7.2.2 Overburden Excavation

Before the portals open excavation, the trees and vegetation within the excavation area shall be cleaned, then the surveyors shall be setting out and pegging. The excavation of the overburden shall be executed by excavator. The excavation construction at the same level shall be subject to the order of "first earth excavation, rock excavation and slope support". The excavated materials are loaded onto 20t dump truck with the excavator to the designated area.

1.7.2.3 Rock Excavation

The rock excavation is conducted after the overburden layer and the weathered rock are removed completely. The rock excavation shall be subject to the bench blasting, the permanent inclined slope is formed by presplitting blasting, for the narrow areas the protection layer will be preserved and excavated with control blasting. Pneumatic drill YT28 and/or hydraulic drilling T35 machine shall be used to drill blasting holes according to the site situation.

The construction procedures of presplitting blasting: operation instruction issuing---surveying and hole distributing---drilling machine in place (with angle corrected) ---drilling hole---hole inspection---charging and blasting—entering the next cycle.

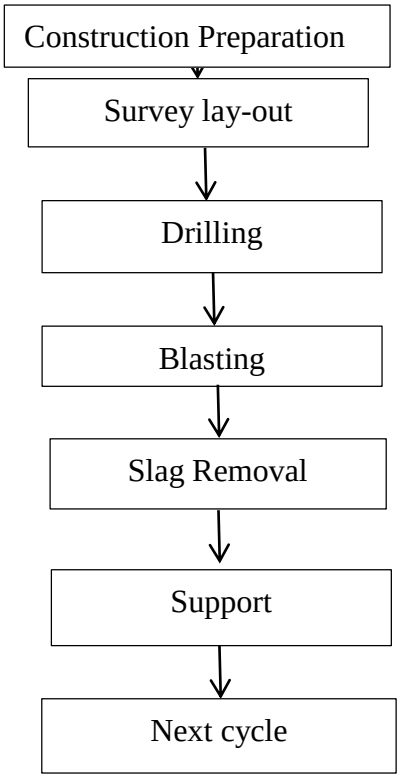
Excavated material transportation shall be loaded with excavator, unused materials are transported with the 20t dump truck to the designated disposal areas, and utilizable materials for the cofferdam to the designated filling place.

The height of the excavation stage is about 15m. Excavation from top to bottom of the inlet and outlet open excavation slop

1.7.2.4 Support

The rock slope will be supported according to the design drawing, rock dowel and steel mesh will be installed before Shotcreting if necessary. The steel mesh (φ6.5mm 200mm*200mm) will be installed base on design and site situation. It should be installed by manpower and fixed by rock dowel, and the shotcrete is sprayed by Shotcrete machine.

The Flow diagram of Open Excavation and Support Construction of the Diversion Tunnel:



1.7.3 Underground Excavation and Support:

The underground excavation for diversion tunnel will be implemented partly with top head area and lower area. The excavation height of the top head area of the tunnel is about 8.3m. The top head area will be excavated by drilling and blasting method, and pneumatic drill will be used for blasting hole. According to the site condition, the lower part area will be excavated by drilling and blasting method with YT28 pneumatic drill or T35 hydraulic drilling machine.

1.7.3.1 Top Heading Tunnel Area

Normally full-section smooth blasting method will be adopted. If the tunnel excavation line (Transition section & Plug section) is an expanded section, the self-making trolley for drilling should be moved from one side to another side to complete one drilling and blasting cycle. The smooth blasting method will be adopted for the perimeter holes with 500~600mm space. And the primary hole space 1000~1500mm. Pneumatic drills (on the self-making trolley) will be used for the hole drilling, excavator and loader for muck loading, 20t dumper for muck haulage from the adit tunnel.

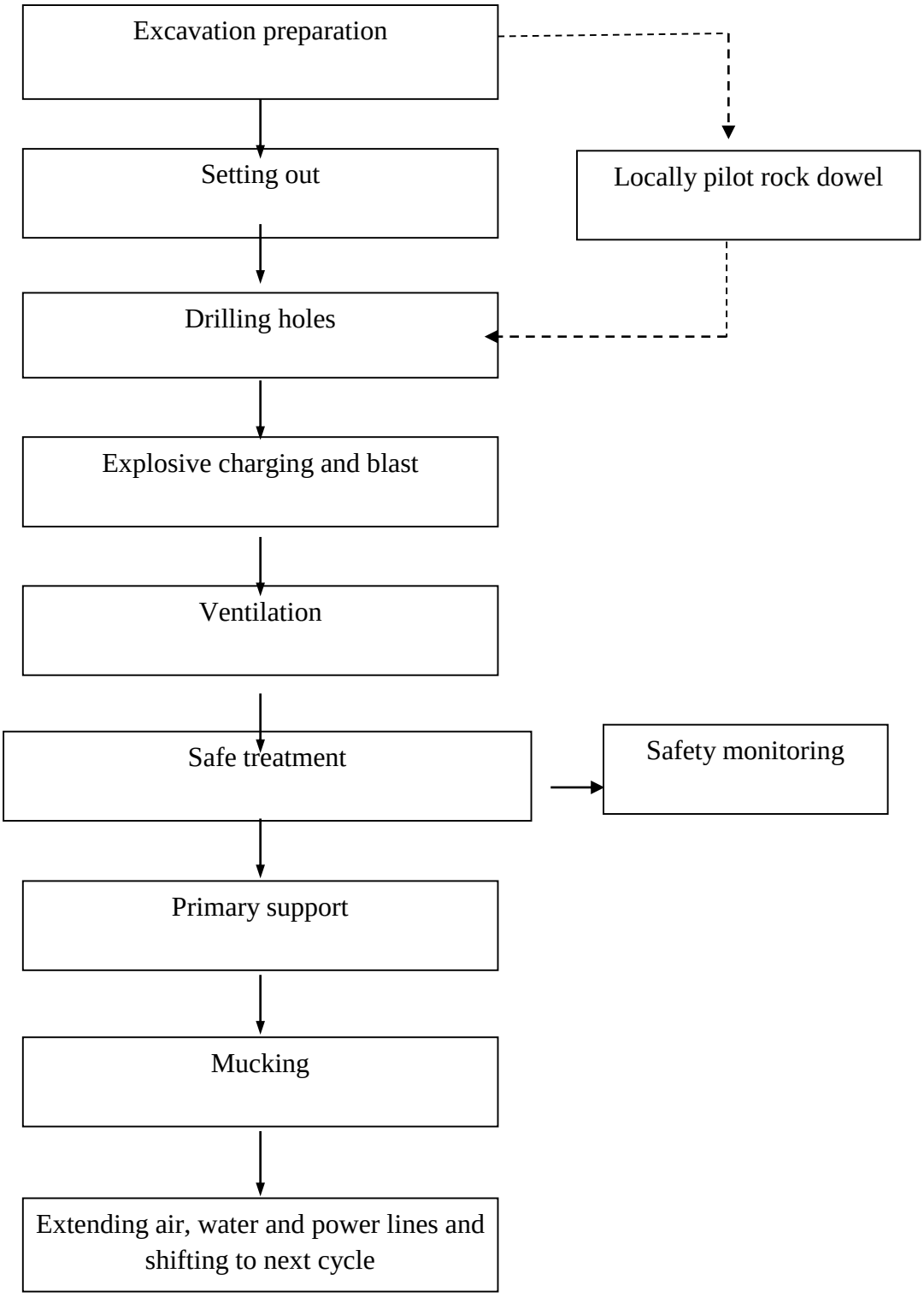
1.7.3.2 Lower Area

Pre-splitting blasting or smooth blasting method will be adopted for the lower area, YT28 pneumatic drill will adopted for the primary holes with the hole space 500~600mm, while T35 hydraulic drilling machine or pneumatic drill for the primary holes. muck loading by excavator and muck haulage by 20t

dumper form the adit tunnel, the elevation of the adit tunnel floor should be lower by drilling and blasting method to adjust to the excavation work of the diversion tunnel.

The blasting network is connected with "V" shape, and the network is connected with detonating cord, and the detonating tube is used for the delay inside the hole. Marking for the drilling points will be done according to blasting pattern. Drilling will be done accurately in terms of location, direction, inclination and depth according to blasting pattern. Before charging, any kind of loose material in holes will be removed. Charging with explosives will be done according to designated sequence in the blasting pattern under supervision of authorized and qualified person. Charging works will be done on charging car or ladder or platform. Workers will evacuate the blasting area. A pre-blast warning announcement (siren) will be done in neighborhoods to inform all residents. A signal man holding warning sign flag will be positioned around the blasting area to keep away residents and workers. Instruments to measure the vibration and noise will be set at the designated place. Blasting will be done under supervision of qualified person. The blasting results will be checked a minimum 15 minutes after blasting.
The rock dowel will be installed after grouting in generally, for the area of top arch of tunnel, the dowel has to be installed before grouting.
The steel mesh will be installed base on design and site situation. It should be installed by manpower and fixed by rock dowel, and the shotcrete is sprayed by Shotcrete machine.
The steel arch that made of I beam steel will be installed for primary support depend on the condition of the surrounding rock identified by the geological engineer of the designer.
Shotcrete will be constructed after rock dowel and / or steel mesh/ribs installation. The rock surface should be cleaned and removed loose materials by air / water jet. The concrete should be supplied from the batching plant or site concrete mixer. The concrete will be wet cured within 2h -- 4h after final set.
The installation position of rock dowel shall be determined according to the design drawing or site designation by the engineer or safety requirement. Survey personnel shall mark the drilling position. Hand pneumatic drill shall be used to drill according to the design hole position, angle and hole depth. After drilling, the hole shall be cleaned. Injection pipe shall be used to inject grout outward from the hole bottom, and then anchor bolt shall be inserted into the hole. After the rock dowel is fixed, mortar mixed with accelerator shall be used to fill the orifice solidly.
Construction procedure: initial Shotcreting→ setting out→ drilling→ cleaning the hole→ grouting→ inserting anchor bolt→ fixing orifice→ treating orifice.
For the surrounding rock sections with relatively poor geological conditions, in order to ensure stability of surrounding rock during tunnel excavation and surrounding rock of excavated section, steel support will be adopted to strengthen support, so as to ensure stability of tunnel excavation.
I-shaped steel is generally adopted to process steel support, which is designed according to the tunnel section and processed in segments in comprehensive processing plant. After steel supports are transported to the construction site, they shall be assembled to be adopted to connect segments.
Construction process of steel support: cleaning excavation face→ initial Shotcreting→ installation of anchor bolt→ installation of steel support →Shotcreting.

Underground Excavation and Support



1.7.4 Marking and Drilling:

1. Marking for the drilling points will be done according to blasting pattern.
2. Drilling will be done by YT28 pneumatic and /or hydraulic drilling machines.
3. Drilling will be done accurately in terms of location, direction, inclination and depth according to blasting pattern.

1.7.5 Charging and Blasting:

1. Before charging, any kind of loose material in holes will be removed.
2. Charging with explosives will be done according to designated sequence in the blasting pattern (Attachment # 03) under supervision of authorized and qualified person.
3. Charging works will be done on charging car or ladder or platform.
4. Workers will evacuate the blasting area. A pre-blast warning announcement (siren) will be done in neighborhoods to inform all residents.
5. A signal man holding warning sign flag will be positioned around the blasting area to keep away residents and workers.
6. Instruments to measure the vibration and noise will be set at the designated place.
7. Blasting will be done under supervision of qualified person.
8. The blasting results will be checked a minimum 15 minutes after blasting.

1.7.6 Mucking:

1. It will be well ventilated by ventilation facilities in order to making good working conditions.
2. Loose material at the crown and side wall parts will be removed by the excavator before start the mucking to prevent the accident.
3. It will be loaded to dump truck by excavator or wheel loader.
4. The Excavated material will be used to raise the level of T6 road and remaining material will be disposed in the designated Disposal Area 25 shown in the Construction General Layout (Attachment # 10).

1.7.7 Rock Classification and Geological Mapping:

1. The geologist will map the excavated surface and record the rock mass grade.
2. Performa sample are given in attachment # 04 respectively.
3. Geological mapping and investigation record will include following items;
   Lithology, strength, weathering, fracturing, joint properties (spacing, persistence, aperture, roughness, infilling material, wall strength, dip/dip direction), ratio of adjustment for joint orientation
   Properties of Geological Structure (fault, fold, shear zone etc.)
4. Recommend reinforcement and its position and direction.

1.7.8 Rock Support:

1. Exposed rock surface will be supported by rock dowels, steel ribs, shotcrete and support girder as mentioned in drawing according to rock mass grade.
2. Shotcrete material will be supplied by batching plant according to approved Mix Design.

Type of Mortar		Dry Mix Shotcrete	Wet Mix Shotcrete	Dowel Grout	Dowel Mortar
Water cement ratio		0.35	0.53	0.48	0.55
Sand ratio (%)		60	60	0	0
Dosage of water reducing (%)		0	1.5	0	0
Dosage of accelerator (%)		6	6	0	0.6
Material used in 1 m^3 concrete (kg)	Water	140	210	551	320
	Cement	400	396	1149	582
	Natural sand	1056	1016	0	1098
	Coarse aggregates	704	678	0	0
	Dosage of water reducing	0	5.94	0	3.492
	Dosage of accelerator	24	23.76	0	0

1.7.9 Diversion Tunnel Convergence Monitoring:

The behavior of a tunnel opening is most drastically manifested in the displacement of the tunnel wall and the rock mass surrounding the tunnel. Convergence of the tunnel walls is by far the most important indicator of tunnel performance and is also relatively easy to measure.

1.7.10 Concrete Work of Diversion Tunnel:

General:

A well-equipped team would be deployed to achieve the concrete lining work of the Diversion Tunnel. The concrete would be of class CY20 mix design (as per table # 4.1 Detailed Design) with general thickness of 0.8~1.0-2.5 meter, as detailed in the design drawings. To achieve this tunnel lining concrete we would use steel frame work of hydraulic type using concrete pumps. First we will complete the invert part concrete from both faces of the diversion tunnel and then circular sectional (Rare wall and Springe line) concrete would take place. Two layers of 16~25 mm ϕ longitudinal reinforcement @ 200 mm c/c & 25~32 mm ϕ cross sectional reinforcement @ 200 mm c/c would be place of grade 60 (420 Mpa deformed bar of steel billet ASTM: A615M, ASTM: A415. After opening of farm work backfilling grouting would take place.

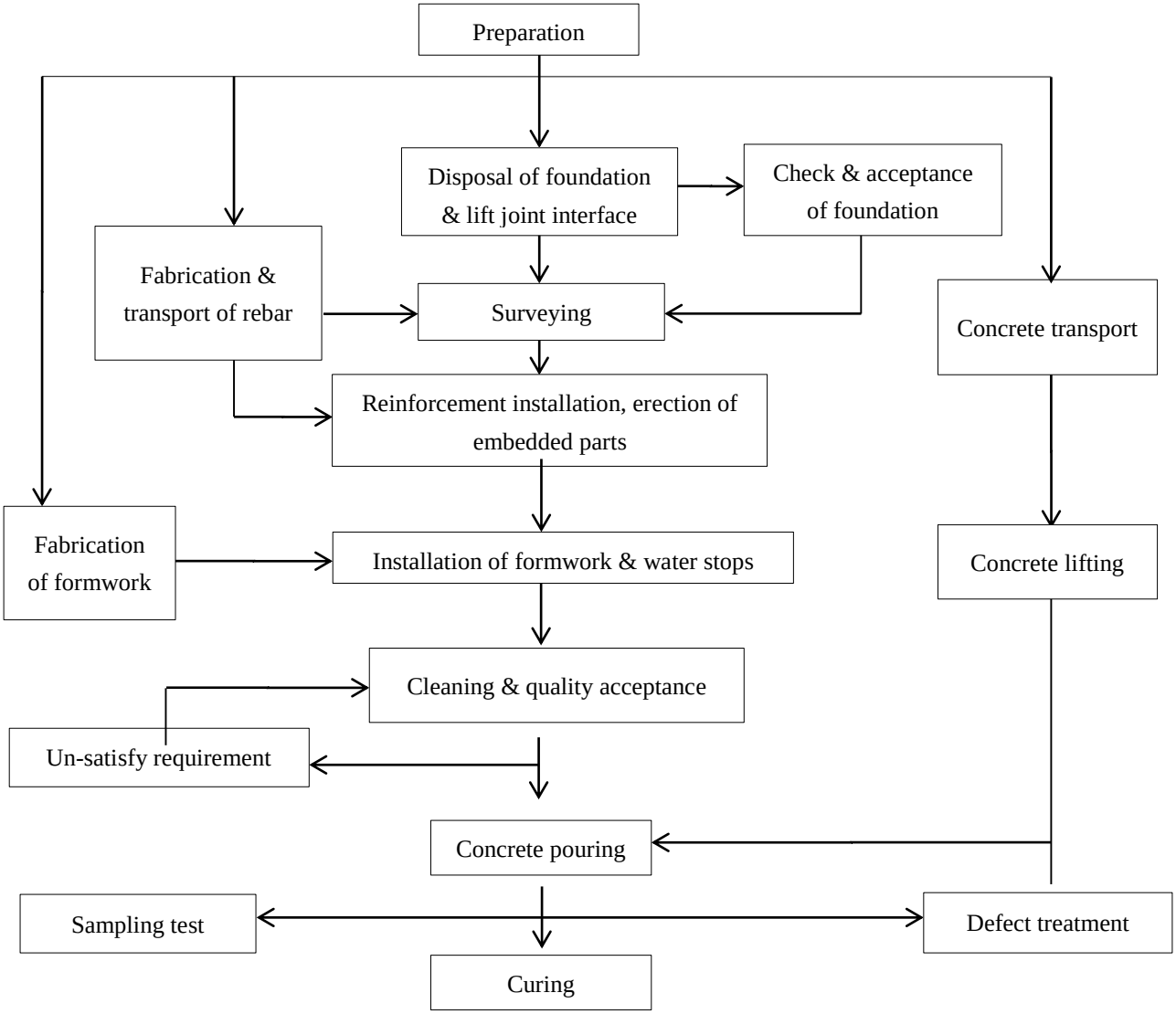
Diversion tunnel concrete lining is foreseen to commence immediately after completion of excavation and tunnel support work. The following sequence of activities is foreseen in Diversion Tunnel.

1) Clean invert and place blinding concrete.
2) Control areas of high water ingress.
3) Place invert reinforcement.
4) Pour invert lining.
5) Place wall and vault reinforcement.

6) Pour wall and vault lining.
7) Finishing works.
8) Execute backfilling grouting (U/S of plug only).

The lining concrete construction method from Ch. 0+000~050 (Transition section) is formwork and scaffolding technologies, and steel moulds trolley pouring method will be applicable to the tunnel body section.

Concrete Pouring Construction Flowchart



1) Disposal of Foundation and Lift Joint Interface

Prior to concrete pouring, foundation surface shall be washed and cleaned to avoid existing of dust, soil and loose rock.

2) Site Surveying

Structure outline shall be marked by surveyor when the foundation clearance is acceptable.

3) Installation of Reinforcement

Reinforcement shall be fabricated in the workshop according to shop drawings, and transported to site by dump truck. Couplings shall be used to connect reinforcement. Particularly, some reinforcement with small diameter shall be connected by lap joint method.

4) Installation of Formwork

Formwork for concrete construction shall be mainly made by steel and wood, which should meet the size of construction structure. And smoothness & steadiness of formwork should be controlled to avoid deformation or collapse.

5) Clean and Acceptance

Concrete pouring work shall be carried out when preparation work of foundation cleaning and vibrators checking is acceptable.

6) Transport of Concrete

8m3 concrete mixers shall be provided to transport concrete to site.

7) Concrete Pouring

Crane, concrete pump and chute shall be provided for concrete pouring. Adding water is extremely prohibited during pouring phase.

8) Curing

In accordance with requirements, surface covering for keeping temperature and water curing shall be carried out within 6h~18h after concrete pouring construction. The curing period shall be no less than 28d under the dry and hot helmet condition.

The sequence placement of transition section concrete pouring flow is as follow: Ch0~21 slab concrete→ CH0~21 sidewall & middle pier concrete (Placement block divided by elevation)→ Ch0~21 arch concrete(Placement block divided by chainage)→ CH35~50 slab concrete → CH35~50 sidewall concrete(Placement block divided by elevation)→ CH35~50 arch concrete(Placement block divided by chainage)→ CH21~35 slab concrete→ CH21~35 sidewall concrete(Placement block divided by elevation)→ CH21~35 arch concrete(Placement block divided by Chainage).

The tunnel body lining concrete will be pouring by steel mould trolley. A 12m long steel mould trolley will be assembled at the cross of the adit for the upstream concrete lining of diversion tunnel, while 2*6m steel mould trolley will be assembled for the downstream.

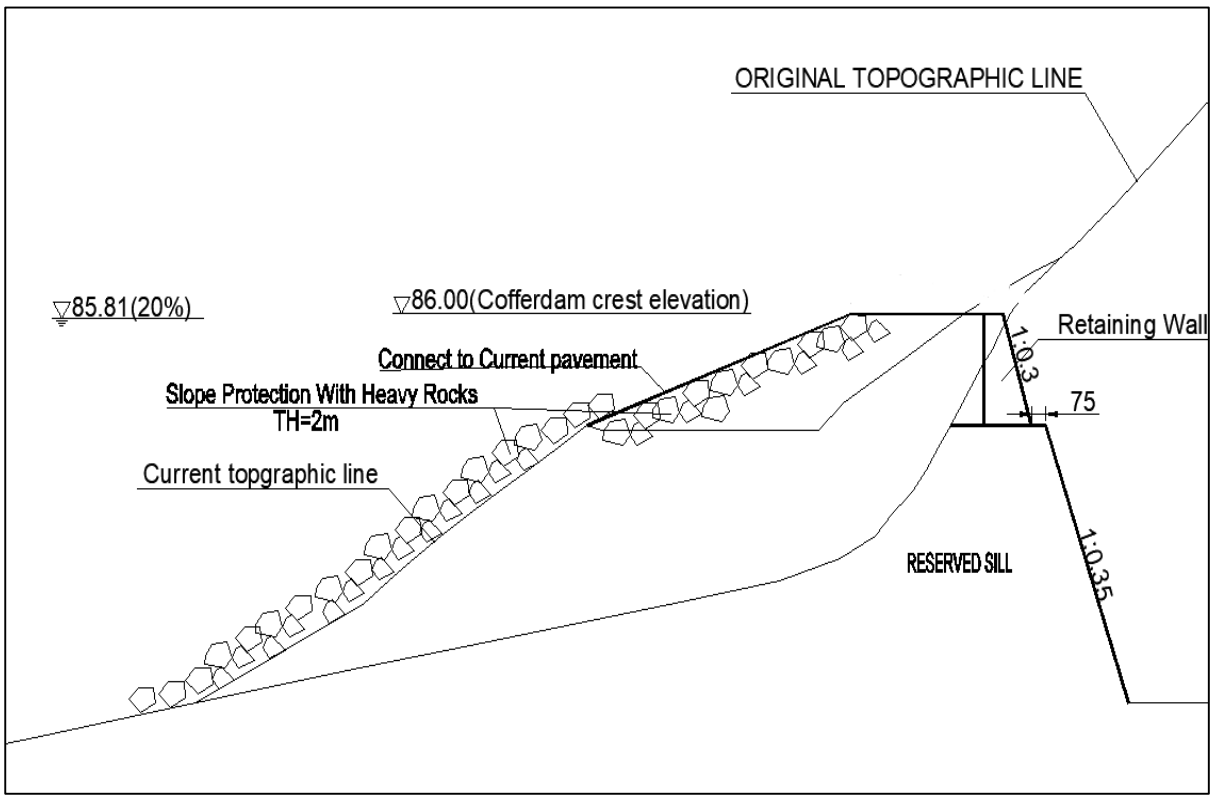
The sequence of gate shaft concrete pouring flow is as follow: Floor concrete (EL64.5~67) → Floor concrete (EL67~68.5) → Pier concreting (EL68.5-71.5) → Pier concreting (EL71.5-74.5) → Pier concreting (EL74.5-77.5) → Pier concreting (EL77.5-80.5) → Pier concreting (EL80.5-83.5) → Roof concreting (EL83.5-86.5) → Roof concreting (EL86.5-89.5) → Roof concreting (EL89.5-92.5) → Body concreting (EL92.5-95.5) → Body concreting (EL95.5-98.5) → Body concreting (EL98.5-101.5) → Body concreting (EL101.5-104.5) → Body concreting (EL104.5-107.5) → Body concreting (EL107.5-110.5) → Body concreting (EL110.5-113.5) → Body concreting (EL113.5-116.0) → Body concreting (EL116.0-118.0) → Embedded part of plug gate installation → Second stage concrete → Formwork removal and clearance.

1.7.11 Method Statement of the Cofferdam Construction

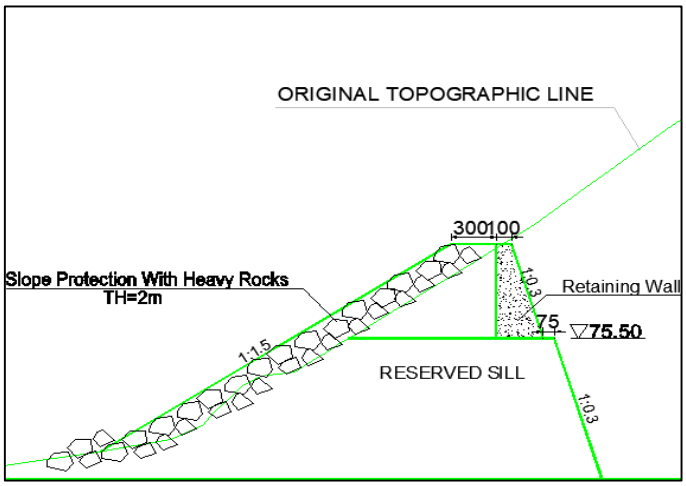
Cofferdam filling work will initiation after finish the excavation and support work of the cofferdam foundation (EL 81m of intake and EL72m of outlet), the foundation rock surface shall be cleaned with air-water jets before the cofferdam filling. The cofferdam designed with three parts: Reserved rock foundation, concrete retaining wall and earth-rock slag with heavy rock slop protection. The concrete retaining wall will be built beside the top of foundation pit, with the top level up to EL86m at intake and EL82.5m at outlet. The top road of intake cofferdam will be connected to existing T6 road.

Consolidation grouting or curtain grouting may be applied for the foundation rock treatment depend on the rock conditions.

Upstream Cofferdam



Downstream Cofferdam



The construction process of cofferdam as follow:

- Construction preparation
- Foundation treatment
- Setting out
- Form erection
- Surface cleaning
- Concrete mixing / transportation / pouring
- Form removal and watering/ protection
- Earth-Rock backfilling
- Slop protection with heavy rock
- Road connect

1.8 MIX PROPORTION DESIGN PLAN OF SHOTCRETE AND ANCHOR ROD MORTAR IN DIVERSION TUNNEL

1.8.1 Specification and Code:

The Technical Specification Package 02 Main RCC Dam, Foundation Treatment & Diversion Facilities should be the main specification which the Subcontractor's operation conforms to. Otherwise, the following specification list in table 8-1 shall be preferred with the approval of the supervisor of the Contractor.

Table 8-1: Specifications and Codes

Specification Code	Name
Cement	
ASTM C150/C150M	Standard Specification for Portland Cement
ASTM C109/C109M	Test Method for Compressive Strength of Hydraulic Cement Mortars
ASTM C151/C151M	Test Method for Autoclave Expansion of Hydraulic Cement
ASTM C188	Test Method for Density of Hydraulic Cement
ASTM C191	Test Method for Time of Setting of Hydraulic Cement by Vicat Needle
ASTM C204	Test Method for Fineness of Hydraulic Cement by Air Permeability Apparatus
Aggregates	
ASTM C33 / C33M - 18	Standard Specification for Concrete Aggregates
ASTM C40 / C40M - 19	Test Method for Organic Impurities in Fine Aggregates for Concrete
ASTM C117 - 17	Test Method for Material Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C127 - 15	Test Method for Specific Gravity and Absorption of Coarse Aggregate
ASTM C128 - 15	Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C131 / C131M	Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136 / C136M	Test Method for Sieve Analysis of Fine and Coarse Aggregate
ASTM C142 / C142M	Test Method for Clay Lumps and Friable Particles in Aggregates
Admixtures	
ASTM C1141 / C1141M	Standard Specification for Admixtures for Shotcrete
ASTM C494 / C494M	Standard Specification for Chemical Admixtures for Concrete
Shotcrete	
ASTM C1102-94	Standard Test Method for Time of Setting of Portland-Cement Pastes Containing Quick-Setting Accelerating Admixtures for Shotcrete by the use of Gillmore Needles
ASTM C1140 / C1140M	Standard Practice for Preparing and Testing Specimens from Shotcrete Test Panels
ACI 506.2	Specification for Shotcrete

1.8.2 Methodology of Application:

The mix proportion of shotcrete and anchor rod mortar and grout shall be applied in the supporting work of diversion tunnel.

1.8.2.1 Application

Shotcrete is frequently used due to better quality, high speed and more convenience than ordinary concrete. Shotcrete can be applied in places where other methods of delivery are difficult or impossible such as elevated, and confined places. Shotcrete can be used in a wide variety of applications including building new structures and reinforcing existing ones. Shotcrete has gained great popularity due to its high strength, durability, low permeability, good bond, countless shape possibilities and easy handling in areas of difficult access.

For the diversion tunnel of Rufiji project, shotcrete is mainly used to the slope stabilization and Underground excavations.

Underground excavations: Shotcrete is used in underground excavations in rocks as well as the advancement of tunnels through altered, cohesion less, and loose soils. As an application, shotcrete is seldom used in isolation, but is used instead in combination with other forms of support and reinforcement such as rock bolting, cable bolts, lattice girders, or steel sets. Shotcrete functions as rock reinforcement in two distinct ways. Being applied to the rock at high pressures, it forces its way into the spaces between intact rock pieces. In this way, it effectively prevents falling of individual pieces, constraining the movements within the mass. Secondly, it gains strength rapidly quickly functioning as a membrane.

Slope stabilization:

Unstable slopes can be graded out if sufficient space is available and thus the need of supporting the slope by any material like shotcrete can be avoided. However, the situations may arise where space is limited, and steep slopes are unavoidable. In these situations, shotcrete might be very useful. Shotcrete permanently covers slopes or cuts that may erode in time or otherwise deteriorate. Slope protection should be properly drained to prevent damage from excessive uplift pressure. Application of shotcrete to the surface of landfills and other waste areas is beneficial to prevent surface water infiltration.

1.8.2.2 Methodology of Shotcrete Mix Design:

Shotcrete design for wet process can be designed like conventional concrete but these mixes contain higher volume of fine aggregates and cement. Shotcrete process can be designed by absolute volume method or by weight. However, in the dry process, usually the water content is not included in the calculation.

Aggregate

Aggregates for shotcrete may contain river sand, crushed sand and crushed stone with particle sizes up to normally up to 10 mm. A typical and recommended gradation of combined aggregates for shotcrete is given the table 8-2:

Aggregates failing to comply with the gradations shown in Table 8-2 may be used if preconstruction testing proves that they give satisfactory results or if acceptable service records are available.

Table 8-2: Typical Aggregate Gradation for Shotcrete

Sieve size, U.S. Standard Square Mesh	Percent by weight passing individual sieves		
	Gradation No. 1	Gradation No. 2	Gradation No. 3
3/4 in. (19 mm)	-	-	100
1/2 in. (12 mm)	-	100	80-95
3/8 in. (10 mm)	100	90-100	70-90
No. 4 (4.75 mm)	95-100	70-85	50-70
No. 8 (2.4 mm)	80-100	50-70	35-55
No. 16 (1.2 mm)	50-85	35-55	20-40
No. 30 (600 µm)	25-60	20-35	10-30
No. SO (300 µm)	10-30	8-20	5-17
No. 100 (150 µm)	2-10	2-10	2-10

Water Cement Ratio

The water-cement ratio for wet shotcrete normally falls within a range of 0.40 to 0.55 for wet-mix shotcrete. Dry mix design shall only include water content enough for the hydration process of cement needed for strength development.

Cement Content

Typical and recommended cement content is given in the following Table 8-3.

Table 8-3: Typical Cement factors for shotcrete

Specified 28-day Compressive Strength		Cement Content	
Psi	MPa	Lb./yd^3	Kg/m^3
3000	21	500-650	300-380
4000	28	550-700	325-425
5000	35	650-850	380-500

Additions

Accelerators are typically added at a rate of 3 to 10 percent by weight of cement. An increased amount can result in a decreased final strength.

Trial Mixing

In general, the properties of shotcrete are related with the process of the spraying, the mix proportion is always determined using the testing panels. If the conditions on site is not satisfied, the trial mixing in the laboratory will use the simulating method to molding the shotcrete by pressing and vibrating the concrete in the moulds.

1.8.3 Illustration Sketches of the Application:

Two kinds of spraying method may be applied for the shotcrete in diversion tunnel depending on the equipments used. Dry mix shotcrete and wet mix shotcrete applications are introduced and illustrated as below.

1.8.3.1 Dry Mix Shotcrete

As illustrated in Figure, the dry shotcrete components, which may be slightly pre-dampened to reduce dust, are fed into a hopper with continuous agitation. Compressed air is introduced through a rotating barrel or feed bowl to convey the materials in a continuous stream through the delivery hose. Water is added to the mix at the nozzle.

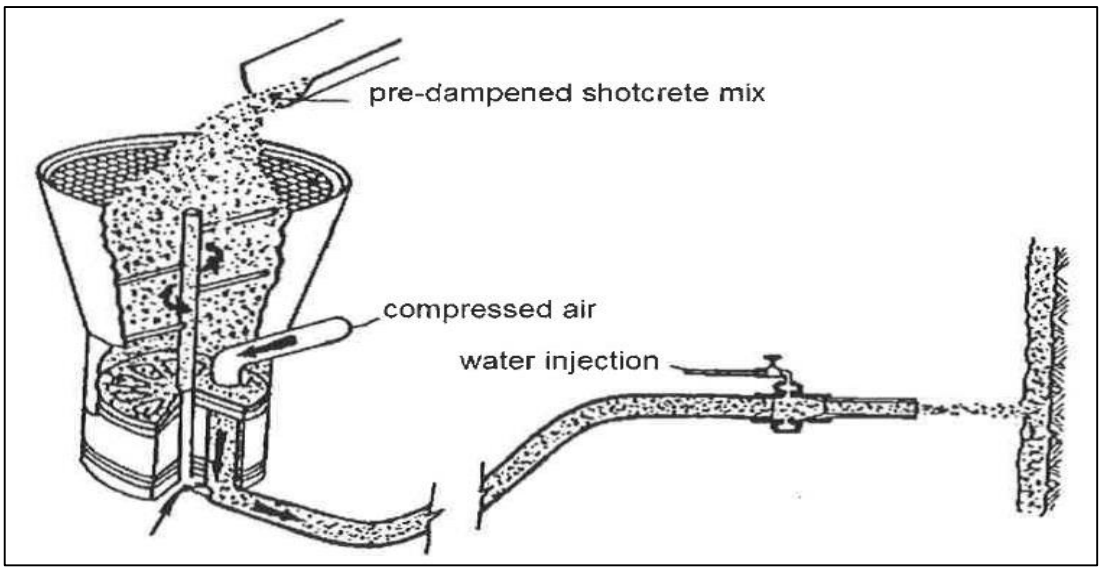


Figure: Simplified sketch of a typical Dry Mix Shotcrete System

1.8.3.2 Wet Mix Shotcrete

In this case the shotcrete components and the water are mixed (usually in a truck mounted mixer) before delivery into a positive displacement pumping unit, which then delivers the mix hydraulically to the nozzle where air is added to project the material onto the rock surface.

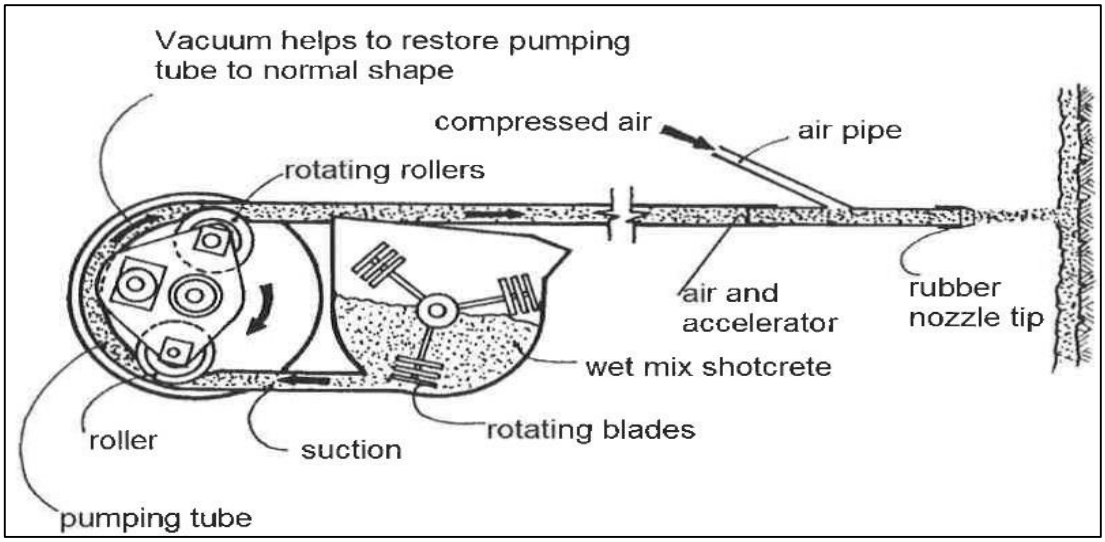


Figure: One typical type of Wet Mix Shotcrete Machine

1.8.4 Raw Material Tests:

1.8.4.1 Cement

Use the type I or type II cement which complying with ASTM C150.

The cement tests shall include: Setting time, density, Soundness, compressive strength, fineness.

1.8.4.2 Fine Aggregates

Use the crushing or natural sand plies with the requirements of ASTM C33.

Fine aggregates tests shall include: Sieve analysis, Clay lumps and friable particles, Material finer than 75 um sieve, coal and lignite, organic impurities, specific gravity, absorption.

1.8.4.3 Coarse Aggregates

Use the crushing coarse aggregates of size 4.75~9.5mm or 4.75 ~12.5mm which the quality complies with ASTM C33. The maximum size of coarse aggregates should be not more than 19.0 mm.

Coarse aggregates tests shall include: Sieve analysis, Clay lumps and friable particles, Material finer than 75 um sieve, coal and lignite, abrasion, specific gravity, absorption.

1.8.4.4 Water Reducing

The water reducer used should comply with ASTM C 494.

Water reducer tests shall include: Water content, setting time, compressive strength, chloride content, Residue by Oven Drying

1.8.4.5 Accelerator

The accelerator used should comply with ASTM C 1141.

Accelerator tests shall include: Setting time, chloride content, Residue by Oven Drying

1.8.5 Requirements of the Mix Proportion Design:

The requirements of the shotcrete and anchor rod mortar are listed in tables 8-4 & 8-5.

Table 8-4: The requirement of shotcrete

Type of Concrete	Design Strength at 28 days	NMSA (mm)	Application Location
Wet-shotcrete	15	12.5	Diversion tunnel entrance and exit
Wet-shotcrete	20	12.5	Side wall and crest in diversion tunnel
Dry-shotcrete	15	12.5	Diversion tunnel entrance and exit
Dry-shotcrete	20	12.5	Side wall and crest in diversion tunnel
Remarks	The strength of the shotcrete is cylinder strength of the cores which drilling from the test panels		

Table 8-5: The requirement of Anchor Rod Mortar/Grout

Type of mortar	Design strength at 28 days	NMSA (mm)
Mortar	25	2.5
Grout	25	/
Remarks	The compressive strength is using cubes of 50mm. Before the trial mixing, the sand should be sieved to pass the 2.5mm sieve	

1.8.6 Procedure of the Trial Mixing:

1.8.6.1 The Required Average Strength of the Concrete:

The required average strength of the shotcrete and anchor rod mortar will be calculated using the formula below. The value of constant t will be chosen as 1.645, the forecast value of the standard deviation will be chosen as 4.5 Mpa.

$$fcr = fc' + t\sigma$$

where
fcr- required average strength;

fc'-design strength specified;

t-a constant depending upon the proportion of tests that may fall below fc';

σ-forecast value of the standard deviation.

Table 8-6: Required Average Strength

Type of Concrete	Design strength specified (MPa) using Cylinders	Design strength specified (MPa) using Cubes	Required average strength (MPa) using Cubes
Shotcrete	15	20	27.4
Shotcrete	20	25	32.4
Anchor Rod	/	25	32.4

1.8.6.2 Trial Mixing Plan:

Determination the Proportion of Aggregates used in Shotcrete

The requirements of grading of the combined aggregates should comply with the tale 8-2.

Trial Mixing of the Shotcrete and Anchor Rod Mortar

The trial mixing of the shotcrete will be carried out using the mass basis. The first estimated mass of the shotcrete shall be chosen as 2300 kg/m3. Then adjust it by measuring the actual density of the concrete. The following table 8-7,8-8 & 8-9 shows some reference information of the trial mixing.

Table 8-7: Reference of Trial Mixing of Wet-Shotcrete

Batch No.	Water-Cement Ratio	Water (kg/m^3)	Cement (kg/m^3)	Testing Items
SC-1	0.45	210	467	1. Density 2. Slump 3. Compressive Strength of 7, 28 Days
SC-2	0.5	210	420	
SC-3	0.55	210	382	

Remarks:

1. The recommend dosage of reducer is in the range of 1.0 ~ 1.5% of the cement by mass, determine the proper dosage to achieve the design slump. The recommend dosage of accelerator is in the range of 6.0 ~ 8% of the cement by mass, the dosage shall be determined to achieve the initial setting of the paste less than 3 minutes.
2. The accelerator should be added after the slump measured, and mix the concrete uniformly and molding using the vibrating table, for the concrete will be set fast, it should be mixed and mould as soon as quickly and compacted by pressing the concrete.
3. The water-cement ratio of each batch should be ensured by checking the moisture content of aggregates before starting the trial, and make sure the work ability of the concrete is available to be used for construction by adjusting the dosage of water reducer.

Table 8-8: Reference of Trial Mixing of Dry Shotcrete

Batch No.	Water-Cement Ratio	Water (kg/m^3)	Cement (kg/m^3)	Testing Items
SC-4	0.3	140	467	1. Density 2. Compressive Strength of7, 28 Days
SC-5	0.35	140	400	
SC-6	0.4	140	350	

Remarks:

1. The reducer will not be used in the dry-shotcrete. The recommend dosage of accelerator is in the range of 6.0-8% of the cement by mass.
2. The accelerator should be added after the slump measured, and mix the concrete uniformly and molding using the vibrating table, for the concrete will be set fast, it should be mixed and molded by pressing and vibrating the concrete.

Table 8-9: Reference of Trial Mixing of Anchor Rod Mortar /Grout

Batch No.	Water-Cement Ratio	Water (kg/m^3)	Cement (kg/m^3)	Testing Items
M-1	0.45	320	711	1. Density 2. Compressive Strength of 7, 28 Days
M-2	0.50	320	640	
M-3	0.55	320	582	
G-1	0.40	/		1. Density 2. Compressive Strength of 7, 28 Days
G-2	0.45	/		
G-3	0.50	/		

Remarks:

1. The estimated density of mortar should be chosen as 2000kg/m3 and the grout for 1700kg/m3, then adjust it by the actual density.
2. The recommend dosage of reducer is in the range of 1.0-1.5% of the cement by mass, determine the proper dosage to achieve the design consistency.
3. The proportion of cement to sand should be controlled in the ratio of 1:1 to 1:2 for the mortar.
4. The water-cement ratio of each batch should be ensured by checking the moisture content of aggregates before starting the trial, and make sure the work ability of the mortar is available to be used for construction by adjusting the dosage of water reducer.

1.8.7 Determination and Submittal of the Construction Mix Proportion:

After acquired the 28 days' compressive strength, the relationship between the water-cement ratio and compressive strength can be curved, from the curve find the proper water-cement ratio corresponding the average required strength, and calculate the mix proportion as the construction mix proportion.

The final reports shall be including all the tests results of the raw material tests.

For urgent using, the laboratory must submit a temporary mix proportion report after the 7 days' compressive strength is achieved.

The accelerator can be added depending on the shotcrete rebound against the rock surface, some place such as slope supporting can be spayed the shotcrete without the accelerator if it is found to be less rebound.

Table 8-10: Design of Mix Proportion for Shotcrete and Rock Dowel Mortar

Type of Mortar		**Dry Mix Shotcrete**	**Wet Mix Shotcrete**	**Dowel Grout**	**Dowel Mortar**
Water cement ratio		0.35	0.53	0.48	0.55
Sand ratio (%)		60	60	0	0
Dosage of water reducing (%)		0	1.5	0	0
Dosage of accelerator (%)		6	6	0	0.6
Material used in 1 m^3 concrete (kg)	Water	140	210	551	320
	Cement	400	396	1149	582
	Natural sand	1056	1016	0	1098
	Coarse aggregates	704	678	0	0
	Dosage of water reducing	0	5.94	0	3.492
	Dosage of accelerator	24	23.76	0	0

1.9 MIX PROPORTION REPORT OF CONVENTIONAL VIBRATED CONCRETE

1.9.1 Specification and Codes

The specification and codes used in the trial mixing are listed in Table 9-1.

Table 9-1: Specifications & Codes

a. General	
Technical Specification Package 2	Main RCC Dam, Foundation Treatment & Diversion Facilities
b. Cement	
ASTM C150	Standard specification of Portland cement
ASTM C109 / C109M	Test Method for Compressive Strength of Hydraulic cement Mortars
ASTM C151 / C151M	Test Method for Autoclave Expansion of Hydraulic cement
ASTM C188	Test Method for Density of Hydraulic cement
ASTM C191	Test Method for Time of Setting of Hydraulic cement by Vicat Needle
ASTM C204	Test Method for Fitness of Hydraulic cement by Air Permeability Apparatus
c. Aggregates	
ASTM C33 / C33M-18	Standard specification of Concrete Aggregates
ASTM C40 / C40M-19	Test Method for Organic Impurities in Fine Aggregates for Concrete
ASTM C117-17	Test Method for Material Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C127-15	Test Method for Specific Gravity and Absorption of Coarse Aggregate
ASTM C128-15	Test Method for Density, Relative Density (Specific Gravity) and Absorption of Fine Aggregate
ASTM C136 / C136M	Test Method for Sieve Analysis of Fine and Coarse Aggregate
ASTM C142 / C142M	Test Method for Clay Lumps and Friable Particles in Aggregates
d. Admixture	
ASTM C494 / C494M	Standard specification of Chemical Admixtures for Concrete
e. Cement and Mix Design	
ACI 211.1	Standard Practice for Selecting Proportions for Normal Heavyweight and Mass Concrete
ASTM C143 / C143M	Test Method for Slump of Hydraulic Cement Concrete
ASTM C172 / C172M	Practice for Sampling Freshly Mixed Concrete
ASTM C192 / C192M	Practice for Making and Curing Concrete Test Specimen in the Laboratory Test
ASTM C1064 / C1064M	Test Method for Temperature of Freshly Mixed Hydraulic- Cement Concrete
ASTM C39 / C39M-18	Test Method for Compressive Strength of Cylindrical Concrete Specimens

1.9.2 Technical Requirements

According to the Technical Specification Package 2, the technical requirement of the conventional concrete is list in the Table 9-2 as following.

Table 9-2: Technical Requirement of the Mix Proportion

Type of Concrete	Specified Strength	Required Average Strength	Specified Age	Designed Initial Slump	Technical Requirements
	fc'(Mpa)	fcr(Mpa)	Days	mm	
Pump Concrete	20	28.5	90	180-220	fcr=fc'+8.5MPa

1.9.3 Raw Material Description

a. Cement

Use the type CEM II/A-L 42.5N cement produced in Dangote company or Type CEM Ⅰ42.5N cement produced in Twiga cement company which comply with ASTM 150.

b. Fly ash

Use the Type F fly ash which produced in JAYCEE company or in Mundra coal plant in India which comply with ASTM C 618.

c. Coarse Aggregates

Use the crushed coarse aggregates of two size, one is from 4.75~19.0mm, the other is from 19.0~37.5mm, the origin of the aggregates is the designated quarry for the Rufiji hydropower project which the quality should comply with ASTM C33.

d. Fine Aggregates

Use the crushed sand produced in the crushing plant of SHC, the origin of which is from designated quarry for the Rufiji hydropower project, and the quality shall be complying with ASTM C33. The fines in the crushed sand should be screened or washed to be in the range specified.

e. Water Reducing

By the trial mixing and comparing the properties using different kinds of water reducing in the site laboratory, the SHC selected the Type HD-SS3 water reducing produced in Beijing Houde Company. which can make the concrete obtain good workability and long-term slump retained. The quality of the water reducing should comply with ASTM C 494 Type F or Type G.

1.9.4 Trial Mixing Plan

For reducing the heat of hydration of the pump concrete of diversion tunnel, the mix proportion will be designed following the principles as below:

- Designed at 90 days: aiming to reduce the cement quantities in the concrete.
- Blending with Fly ash: The Type F fly ash is helpful lowering the heat of hydration in the concrete. The trial mixing plan is list in the table 9-3.

Table 9-3: Trial Testing Plan of the Pump Concrete used in the Concrete Lining of Diversion Tunnel

Type of Cementitious Material	W/(C+F)	Sand Ratio (%)	Fly ash Percent (%)	Designed Slump (mm)	Material in 1 cube meter concrete (kg/m^3)			Testing Items
					Water	Cement	Fly Ash	
Dangote CEM II/A-L 42.5N+ 20% Mudra Fly ash	0.4	41	20	180～220	165	330	83	1.Slump 2.Density 3.Compressive strength at 7 days, 28days
	0.45	41	20	180～220	165	293	73	
	0.5	41	20	180～220	165	264	66	
	0.55	42	20	180～220	165	240	60	
	0.4	41	30	180～220	165	289	124	

Twiga CEM I42.5N+ 30%Mudra Fly ash	0.45	41	30	180～220	165	257	110	,45 days and 90 days
	0.5	41	30	180～220	165	231	99	
	0.55	42	30	180～220	165	210	90	
Dangote CEM II/A-L 42.5N+ 20% JAYCEE Fly ash	0.4	41	20	180～220	165	330	83	
	0.45	41	20	180～220	165	293	73	
	0.5	41	20	180～220	165	264	66	
	0.55	42	20	180～220	165	240	60	
Twiga CEM I42.5N+ 30% JAYCEE Fly ash	0.4	41	30	180～220	165	289	124	
	0.45	41	30	180～220	165	257	110	
	0.5	41	30	180～220	165	231	99	
	0.55	42	30	180～220	165	210	90	

1.9.5 Submittal of the Construction Mix Proportion

After obtaining the 90 days' compressive strength, the relationship between the water cementitious material and compressive strength can be curved and from which the construction mix proportion can be selected. If the 90 days' compressive strength can't have obtained before the concrete placing, the SHC will submit the 45 days' test results and give the recommended mix proportion for construction firstly.

1.10 HEALTH, SAFETY AND ENVIRONMENT MANAGEMENT PLAN

Objective of the HSE plan is to achieve the specific HSE target/goal essentially defined by the contractual and legal HSE obligation and according to the demands of the internationally acceptable standards. Mainly the objective of the HSE at every level will be the assessment of hazards, planning to control those hazards; provision of adequate resources to achieve prescribed zero accident level.

1.10.1 Construction Operation Activities in Tunnel:

Main operational activities will target the following:

- Marking and drilling.
- Charging and blasting.
- Mucking.
- Face mapping.
- Shotcrete.
- Installation of wire mesh.
- Installation of rock dowel.
- Installation of support steel rib.
- Shotcrete.

All the activities will be monitored by the HSE staff. Following generic issues will be considered every day during tunnel visit.

- The tunnel will consider as confined space thus its entry procedures will be implemented.
- Air quality inside tunnel.
- Gas test shall be performed before start and in intervals period according to job type and time.
- Explosive material handling and transportation.
    - Use, handle, and transport explosives in accordance with local and national explosives safety regulations and internationally accepted standards.
    - Assign certified blasters or explosives experts to conduct blasts.
    - Actively manage blasting activities in terms of loading, priming, and firing explosives, drilling near explosives, misfired shots, and disposal.
    - Adopt consistent blasting schedules, minimizing blast-time changes.
    - Implement specific warning devices (such as horn signals and flashing lights) and procedures before each blasting activity to alert all workers and third parties in the surrounding areas (for example surrounding communities). Warning procedures may need to include traffic limitation along roadways.
    - Conduct specific personnel training on explosives handling and safety management.
    - Implement blasting-permit procedures for all personnel involved with explosives (handling, transport, storage, charging, blasting, and destruction of unused or surplus explosives).
    - Ensure that qualified personnel check blasting sites for malfunctions and unexploded blasting agents following the blast and prior to resumption of work.
    - Implement specific audited procedures for all activities related to explosives (handling, transport, storage, charging, blasting, and destruction of unused or surplus explosives) in accordance with relevant national or local regulations and internationally recognized fire and safety codes.

- Use qualified security personnel to control transport, storage, and use of explosives on site. Blasting activities may cause accidental explosions and affect surrounding populated areas. In addition to the prevention and control measures described above, the following measures are recommended to address risks to nearby communities:
  1- Other parties' awareness and emergency preparedness and response planning should be undertaken, including control of third-party access to blasting areas.
  2- Blasting should be conducted according to a consistent timetable. If changes to the blasting timetable occur, nearby parties and subcontractors should be immediately informed of those changes

- Proper ventilation inside tunnel.

  - Ventilation systems should be appropriate for the workplace activities and be able to maintain work area concentrations of contaminants at safe levels. Ventilation operators and maintenance personnel should undergo adequate training with respect to such issues as explosive atmospheres, products of combustion, dust, and diesel fumes.
  - Tunneling works should ensure a safe and clean source of air for all areas expected to be occupied by workers. Recommended management strategies include the following:
    1- Ensure surface ventilation units and associated auxiliary equipment are located and managed to eliminate hazards that could jeopardize ventilation equipment performance or ventilation air quality (for example, emissions sources and inflammable or explosive materials should not be stored near air intakes).
    2- Operate auxiliary fans to avoid the uncontrolled recirculation of air.
    3- Remove all persons from the tunnel, if the main ventilation system is stopped other than for a brief interruption.
    4- Barricade all areas that are not being ventilated and post warning signs to prevent inadvertent entry
    5- Provide H2 S and carbon dioxide (CO2) detectors and response training wherever these gases may accumulate.
  - As appropriate, thermal conditions should be monitored to identify when heat could adversely affect workers, and protective measures should be implemented. Temperatures should be maintained at levels reasonable and appropriate for the activities undertaken. Other practices should include heat tolerance screening, acclimatization, water breaks, and adoption of suitable work-rest regimens.

- Management of tunnel status (Check in/ Check out).

- illumination.

  - Underground illumination should be adequate for the safe performance of all work functions and the safe movement of workers and equipment.
  - Separate and independent emergency light sources should be provided at all places where a hazard could be caused by a failure of the normal lighting system. The system should turn on automatically, should be adequate to allow the workers to conduct an emergency shutdown of machinery, and should be tested on a regular basis.
  - Underground workers should always have an approved cap lamp in their possession while underground.

- Work at height (Using basket & Scaffolding& Ladder).

- Scaffold erection and dismantling.

- Using air compressor.

- Using of Power and Hand Tools

- Vehicle Movement and traffic control

- Pedestrian walking inside the tunnel.
- Dust control inside the tunnel.
  - Over and above the risks associated with dust covered in the General EHS Plan, dust control should be fully integrated into tunneling procedures, particularly associated with blasting, drilling, and material transport and dumping. Minimization of dust is essential to improve visual clarity in an underground setting and improve workers' health.
- Manual Handling.
- Hazardous materials Handling and storage
- Workplace Environment (Heat / Noise / Dust).
- Firefighting Equipment (Fire extinguishers / Fire blanket / Sand buckets)
- Fuel handling and refueling
- Entrance in tunnel after blast.
- Respiratory issues and the adequacy of PPE, s use.
- Proper treatment of tunnel drainage.
- Induction training and other trainings.
- Waste Management
- Working at Night
- Avoid gas Equipment within the Tunnels

1.10.2 Air Quality inside Tunnel:

Air quality will be monitor on daily basis mainly dependent on the activities inside the tunnel, after every blast air quality will be checked within 25-30 minutes until the assurance of HSE staff no one will be allowed to enter inside the tunnel. Air quality test will also be carried out during mucking in any case of increasing the level of gases activity going on will be stopped until the normalization of gases within the limits. Other than this air quality test will also be carried out whenever required.

1.10.3 Explosive Material Storage Handling and Transportation:

To provide the safe working environment to all workers is the first and foremost priority of JV-ACEE, the storage handling and transportation of the blasting material will be done according to the manufacturer requirement which will be acceptable according to international standards and contract requirement. The main environmental and safety issues related with blasting material such as temperature, humidity and vibration control measures will be checked and addressed to the employees involved in activates.
For the checking of blasting material storage by the HSE will include the following

- Kept dry and ventilated.
- Kept as cool as possible and kept free from excessive or frequent change of temperature.
- Protected from direct sunlight.
- Kept free from constant excessive vibration.

For the transportation of blasting material from explosive storage HSE staff will be informed so that after the clarification HSE staff will allow the transportation and recheck if the blasting material is brought back in explosive storage. Explosive material will be allowed to be transported on designated vehicles.

1.10.4 Management of Tunnel Status (check in/check out procedures):

All the employees entering inside tunnel have to maintain a check-in/check-out procedure to ensure that accurate number of persons underground and to prevent unauthorized persons from gaining access to the tunnel. HSE staffs present at site will counter check the status for improper check-in/check-out warning letters will be issued to employees for their violation and according to the HSE procedures every employee will be given three chances on the completion of three warning letters employee will be removed from job.

1.10.5 Proper Lightning Inside Tunnel:

Proper lightning arrangements inside the tunnel will be maintained in such a way so that lamp at every interval will not exceed the length of 15m fitted along the one side wall of the tunnel, illumination on the horizontal plan at the floor level will not be less than 10 Lux. While in any case of inadequate lightning the placement of light lamps fitted at one side wall of the tunnel will be lowered. Whatever the height of the light bulbs adjusts by the contractor the intensity of the light should never be below 10lux. While on the face of the tunnel the intensity of light will be maintained 160lux by the usage of moveable lamps.

1.10.6 Work at Height:

According to the HSE procedures no one will be allowed to work more than the height of 2m without the usage of body harness. In case of the usage of scaffolding inspection will be carried out by the HSE site staff.

1.10.7 Entrance inside Tunnel after Blast:

At the time of blast HSE Engineer will be present at tunnel, blast will be carried out according to the required HSE procedures, Air quality test will be carried out by the HSE staff after 30 minutes of the blast. After the assurance of the HSE staff employees will be allowed to enter inside the tunnel. If the concentrations of gases are more than normal level no one will be allowed to enter until the gases come to normal level air quality test will be carried out again to ensure the safe working atmosphere inside tunnel. Checking of the face and unexploded material will be done by the blasting supervisor after HSE staff allows the employees to enter inside tunnel.

1.10.8 Respiratory Issues and the Adequacy of PPE's Use:

It has been declared mandatory to wear mask and visible jacket before entering inside the tunnel while usage of safety shoes and helmet is mandatory and basic requirement at the entrance of any site of Rufiji Hydropower Project. Actions will be taken against violators by the HSE rules and regulation. While the usage of the other PPE's like goggles, coverall, apron, etc. will be done according to requirement as prescribed by the HSE.

1.10.9 Proper Treatment of Tunnel Drainage:

Drain water inside the tunnel will be channelized through drain ditch through which it will come to the sedimentation tank built outside the tunnel after getting treatment in sedimentation tank it will be directed to the other sedimentation tank where it will get final treatment after the removal of sludge and hazardous waste it will be allowed to flow down further. Cleaning of sedimentation tanks will be done on daily basis HSE engineer appointed for the tunnel area will regularly monitor the cleaning sedimentation tanks on regularly basis. After cleaning with the help of excavator sludge will be sent to the disposal site area in dump truck.

1.10.10 Risk Assessment Plan:

Risk Assessment will be done to eliminate and prevent hazards in the tunnel. This is likely to result in fewer worker injuries and illnesses; safer, more effective work methods; for a job hazard analysis to be

effective, management will demonstrate its commitment to safety and health and follow through to correct any uncontrolled hazards identified. Refer to attachment # 08. Risk Assessment Plan.

1.10.11 Induction Training and Other Trainings:

JV-ACEE will ensure that all new employees have taken orientation HSE training. Every employee will undergo the HSE Induction course by JV-ACEE in-house trainer. Required safety equipment will be issued at the time of orientation. Other trainings will also be done according to the requirement of the job or activities for the tunnel workers it will be ensured that every worker has taken these trainings.

- Confined space training.
- Blasting material storage, handling and transportation training.
- Permit to work (PTW) training.
- Fire protection and prevention.
- First Aid training.
- Excavation Safety.
- Work at height.

1.10.12 Emergency Preparedness and Response /Emergency Plan:

Emergency response team will be available and fully equipped by breathing apparatus devices and other required emergency tools, Emergency plan will be pasted in front of Diversion tunnel and communicated with all employees, evacuation siren(Alarm) will be installed in the entrance of the tunnel. Muster points will be located for each site for the tunnel worker. In order to deal with all kind of situations emergency plan will be pasted and communicated, emergency contact list will also be placed and pasted on all site areas.

1.10.13 General Safety Precautions:

1. Personnel working inside & outside the tunnel must wear personal protective Clothing/Equipment as indicated by the HSE staff accompanying Permit to Work.
2. Warning Notices and barriers must be erected, sufficient to avoid accidental entry, exclude unauthorized personnel at a safe distance.
3. Excavation equipment must only be used by persons trained in its correct use.
4. Powered equipment must not be left running unattended.
5. Barricades with warning devices and flashing lights as needs shall be installed alongside of site area wherever people or vehicles are exposed and warning lights placed at night.
6. Usage of the body harness above the height of 2m is essential.
7. Scaffolding and other structure used as working platform must be inspected and tagged by the HSE staff.

1.11 DIVERSION TUNNEL SURVEY WORK

The survey of the diversion tunnel will show how to measure, as built and control the lining of the diversion tunnel with the most practical ways.

Index:

- Transfer control points to inlet, outlet and adit of the diversion tunnel.
- Checking the connection of the secondary control stations.
- Navigating the tunnel and tunnel alignment.
- Checking the alignment.

- Tunnel control.
- Lining the tunnel.
- As-built the tunnel.
- Instrumentations.

1.11.1 Transfer Control Points to Inlet, Outlet and Adit of the Diversion Tunnel:

1. Using GPS Main control network must be fixed surrounding all the project boundary generated from the main control which we received from the Client.
2. The main control stations received from the client will be measured and adjusted by the GPS and adjusted by L.G.O Software and the adjustment coordinates should be compared with the coordinates from the client to see the errors that may exist.
3. A secondary control points should be fixed at the excavation locations, measured and adjusted as a 3D network.
4. Secondary control survey should be steel pillars or concrete points with a survey nails.
5. The coordinate system that should be used is Arc1960 (mean), UTM-37south and the geiod model is EGM-96.

ID	N (m)	E (m)	H (m)
BFQ477	9141550.054	377906.312	376.25
BM00	9137595.848	372921.042	163.781
BM12	9137358.471	373462.326	192.295
BM13	9139282.203	373116.976	226.864
BM16	9137702.030	372962.995	168.340
BM17	9128887.317	376470.589	178.460
BM20	9137803.236	376329.425	141.39
ST01	9138106.190	370947.158	143.82
ST02	9137151.103	372082.891	150.36
ST03	9137008.235	373197.503	148.589
ST04	9139584.924	373856.472	191.46
ST05	9138530.954	375061.403	153.69
ST06	9135871.281	376069.837	252.913
ST07	9135627.155	373527.075	176.69
ST08	9137600.621	374610.850	175.105
ST09	9138121.893	373712.002	176.130
ST10	9129451.715	377208.134	154.88
ST11	9125760.421	376238.987	177.774
ST12	9123823.325	377049.404	176.602
ST13	9121060.732	376241.475	176.75
ST14	9119690.468	375441.450	190.58
ST15	9116817.614	376580.066	182.310
ST16	9113439.651	377456.883	189.723
ST17	9115959.804	376188.923	175.49
ST18	9111064.941	377322.681	193.15

1.11.2 Checking the Connection of the Secondary Control Stations:

1. Using total station and traversing sets a control observation should be performed.
2. The control measurement should measure at least 4 sets in two faces to all the available seen points.
3. The network must be adjusted using least square adjustment technique provided by L.G.O Software or with any software uses least square adjustment technique.

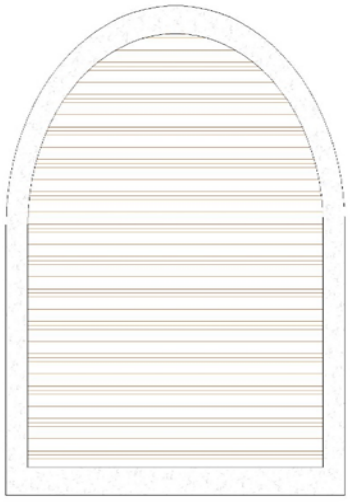
4. The total station that will be used should be auto targeting and aiming TS to avoid the personal errors.
5. Every point in the secondary network should be occupied as total station point and all the points should be measured from it.
6. The adjustment will show the quality of the measurement and if it's exceeds 3mm per 1000 meter the measurement should be repeated.
7. Loop levelling or double levelling should be performed to check the levels of all the network and should be adjusted to correct the levels if there is any variance had been found.

1.11.3 Navigating the Tunnel and Tunnel Alignment:

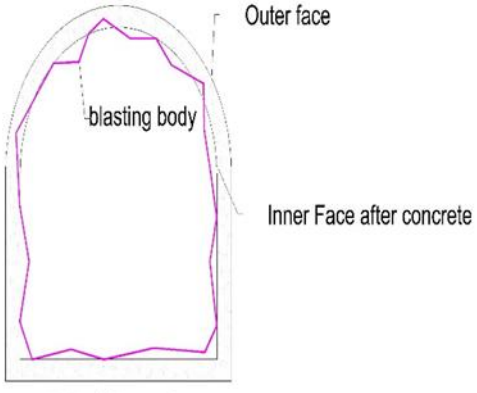
1. At the start of the excavation the concrete control points will be used to navigate the tunnel.
2. After excavating 60 meters a tunnel console or bracket should be fixed as the first inner tunnel control point.
3. A surveyor with a total station will be present while drilling the blasting cores to mark the center of the tunnel and the points of the core.
4. After blasting the surveyor will measure the inner face of the tunnel and a survey engineer will compare it with the tunnel model and get and till the locations that need repair.
5. Tunnel alignment will be defined by 3.D Points for the center line will be provided.

1.11.4 Checking the Alignment:

1. Every 10 (We suggest every 2,0 m for avoid under break excavation interference whit the reinforce bar), meters the inner face of the tunnel will be measured and compared with the design face.
2. From the as built the center of the tunnel as well as the side edges will be drawn and adjusted to fit the tunnel best fit geometrical body.
3. From the tunnel control the surveyor will stake out the center of the tunnel and the edges of its geometrical design to keep in the correct alignment.



D.T Typical Cross section

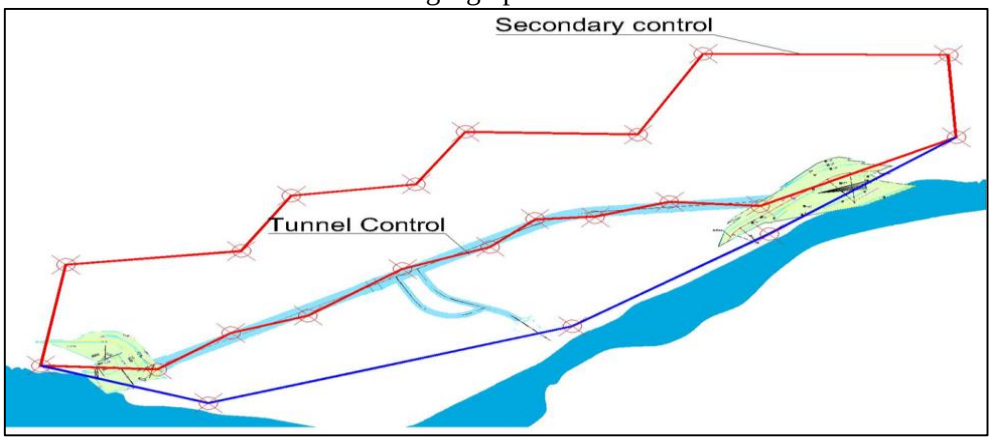


D.T Typical Cross section

1.11.5 Tunnel Control:

1. The frequency of fixing the console will be every 60-meters minimum and max by 100 meters depending on the tunnel alignment criteria (100 meters for the straight line and 60 at curves). And these distances can be varying according to the site and the tunnel status.
2. A control measurement inside the tunnel should be performed every time after fixing a new bracket in the tunnel.
3. Adjusting the measurements should perform least square adjustment methods.

4. A control observation from outside the tunnel to the last fixed console inside the tunnel should be performed along all the tunnel and adjusted every 250-meters maximum.
5. All the brackets should be fixed as a zigzag open traverse.

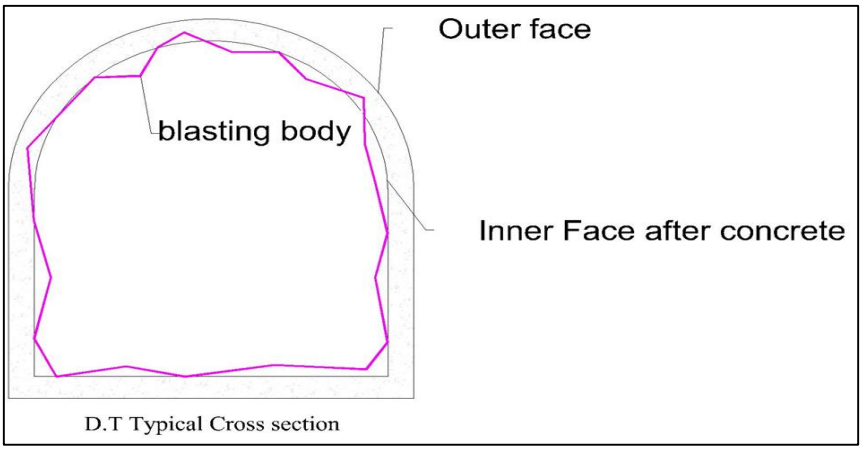


1.11.6 Lining the Tunnel:

1. From the as-built that will be performed the tunnel lining and the edges Carving from the blasting will be repaired and re-measured from the survey to assure that we reach the required tolerance as per the civil work needless.

1.11.7 As-built the Tunnel:

1. After shotcrete survey should provide an as built of the tunnel inner body compared by the design with the deviations on it to be submitted to the client.



1.11.8 Instrumentation:

1. Leica total station ts16 or equal with an angular error of 3- seconds max.
2. Leica NA2 Digital level with an error of 2 mm of 1000 meters or equal to it.
3. Leica GNSS System GS15 or equal.
4. Traverse kits.


Leica


Viva
Leica


Leica


Leica

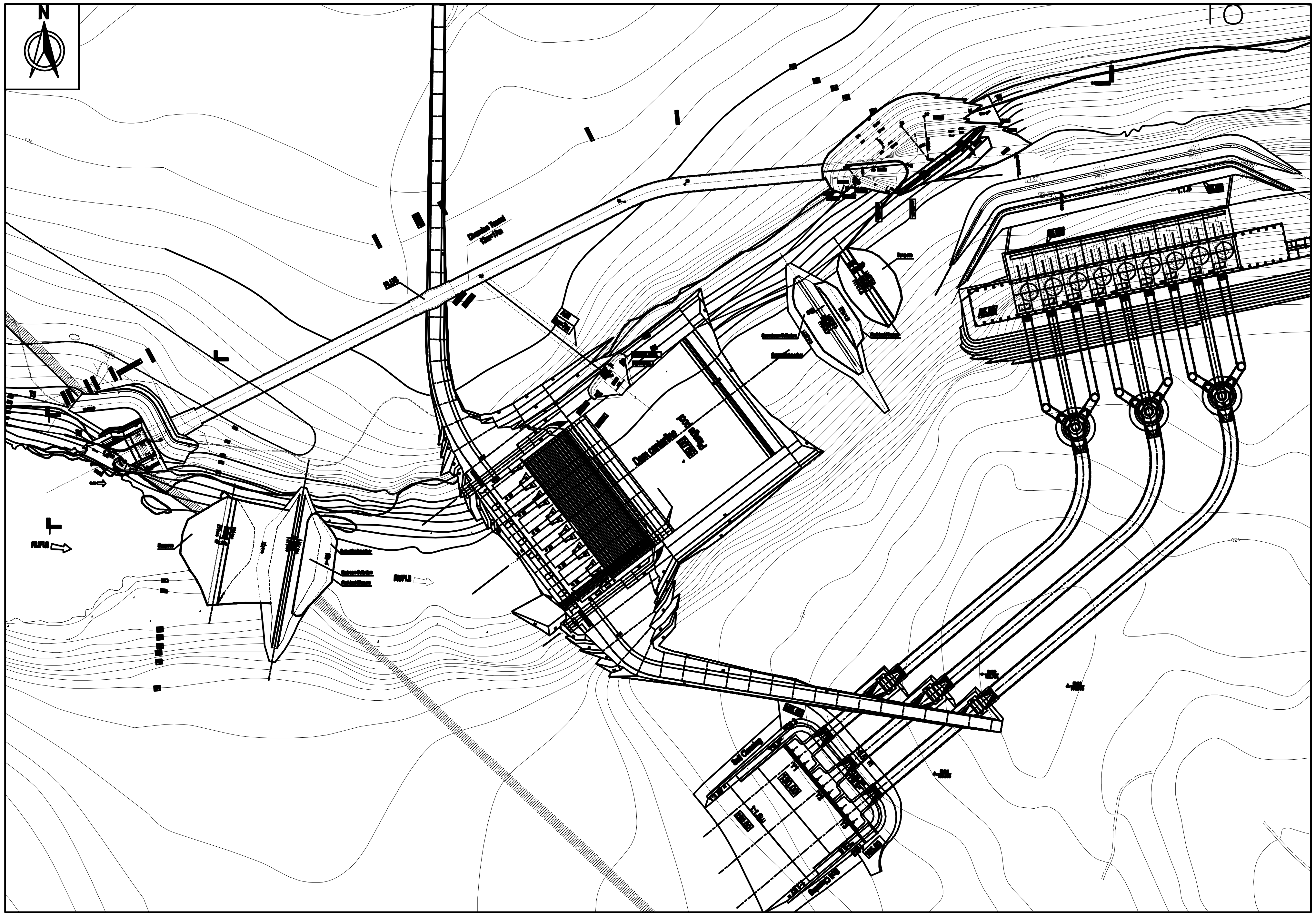
ATTACHMENTS

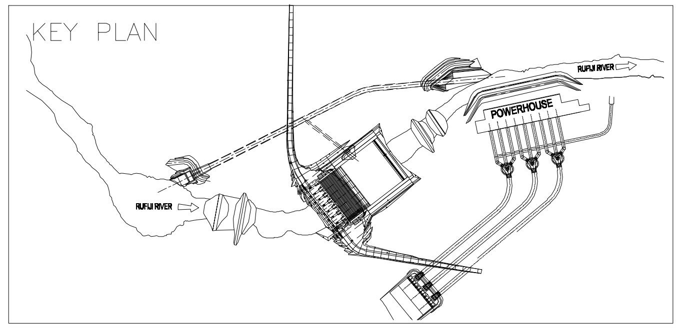
Attachment # 01: Attachment # 01-Design Drawings
Attachment # 02: Electric and Water Supply Systems
Attachment # 03: Blasting Pattern
Attachment # 04: Face Mapping Performa
Attachment # 05: Checklist for Tunnel Steel Support
Attachment # 06: Explosivity /Gas Monitoring Sheet & Confined Space Entry/Exit
Attachment # 07: Explosive and Detonator Register Format
Attachment # 08: Risk Assessment Plan
Attachment # 09: Construction Schedule of Diversion Tunnel
Attachment # 10: Construction General Layout

ATTACHMENT # 01
DESIGN DRAWINGS.

LAYOUT PLAN OF CONSTRUCTION DIVERSION

SCALE A





Construction Diversion Procedure

Diversion period (year, month)	Design standard (year)	Design flood (m³/s)	Top elevation of weir (dam) (m)	Upstream water level (m)	Downstream water level (m)	Water retaining structure	Drainage structure
From June 15, 2019 to June 14, 2020	Main channel overflow						
From June 15, 2020 to November 15, 2020	20 (dry season)	1861	91.50 (Cofferdam)	90.0	74.68	cofferdam	Diversion tunnel
From November 16, 2020 to June 14, 2021	20 (flood season)	10488	90.00m (Dam retaining section), dam notch elevation 74.00m, width 78m	103.38(In front of cofferdam) / 94.95 (In front of dam)	86.74	Dam	Diversion tunnel + dam gap
From June 15, 2021 to November 15, 2021	20 (dry season)	1861	91.50 (Cofferdam)	90.0	76.48	Dam	Diversio n tunnel
From November 16, 2021 to June 14, 2022	100 (flood season)	15960	190.00m (dam)	181.28	91.19	Dam	Surface hole in dam
After June 15, 2022	Spillway						

Coordinates

Number	X Coordinate(m)	Y Coordinate(m)
D0	[illegible]	[illegible]
D1	[illegible]	[illegible]
D2	[illegible]	[illegible]
D3	[illegible]	[illegible]
S1	9137635.9229	373050.6962
S2	9137726.3237	372933.9351

Notes:

1. This picture is the Rufiji Hydropower Station Project,Plane Layout of Construction Diversion System.
2. The dimensions of this diagram are all cm except for elevation, coordinates and Mileage measured in M.

0 5 10 25m

GRAPHIC SCALE 1:500

Originator

The Arab Contractors
OSMAN AHMAD OSMAN & CO.
المقاولون العرب
عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

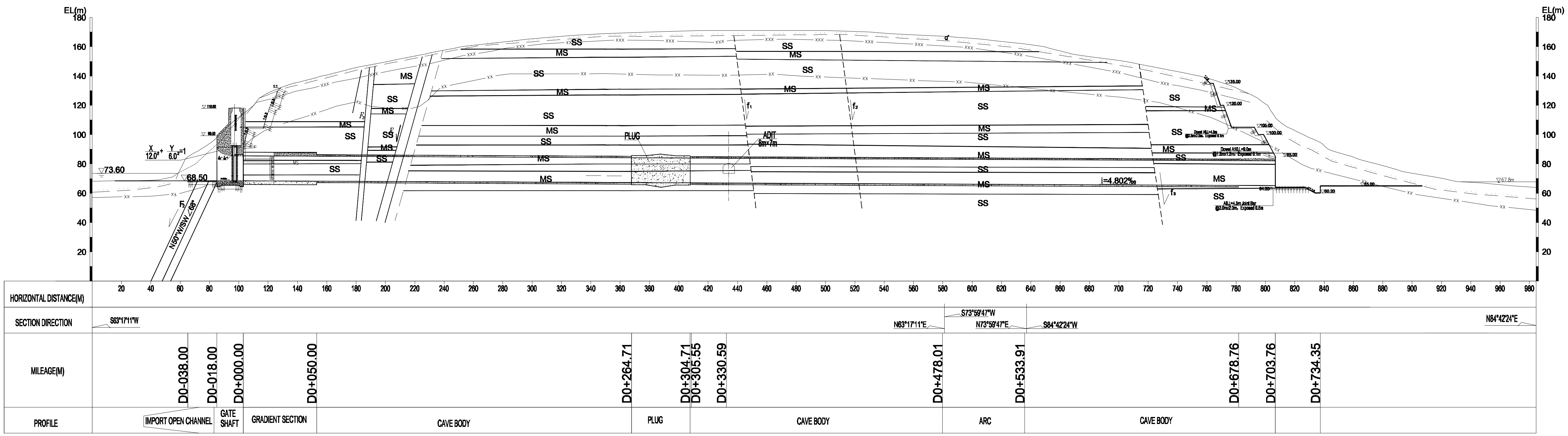
Title: Basic Design

DIVERSION SYSTEM
LAYOUT PLAN OF CONSTRUCTION DIVERSION

Type: BLACK	Scale: **As Shown**	Size: A3
Document no. RUF-SHC300-ULX-&CTA010-000001	Rev. B	PAGE NO. 1/1

LONGITUDINAL PROFILE OF DIVERSION TUNNEL

SCALE A



LEGEND

- Rubbles ans angular coddles (Collapse)
- Sand gravel (Alluvial)
- SS Sandstone
- MS Mudstone
- The boundary between overburden and bedrock
- Strong— unloading boundary
- Strong-weathering boundary
- Medium-weathering boundary

Notes:

1. This picture is the Rufiji Hydropower Station Project,Longitudinal profile of diversion tunnel Drawing.
2. The dimensions of this diagram are all cm except for elevation and Mileage measured in M.

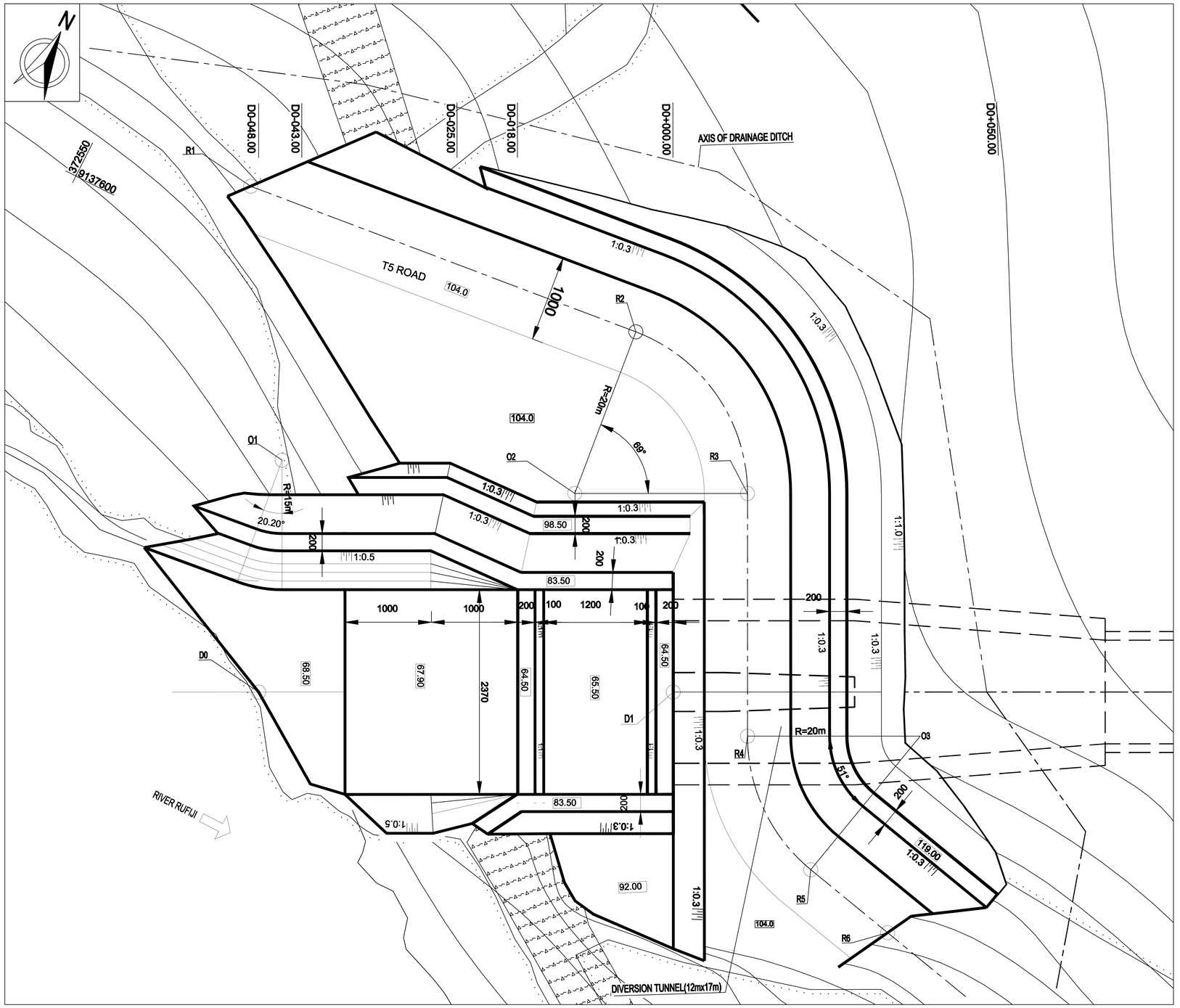
0 5 10 25m

GRAPHIC SCALE 1:500

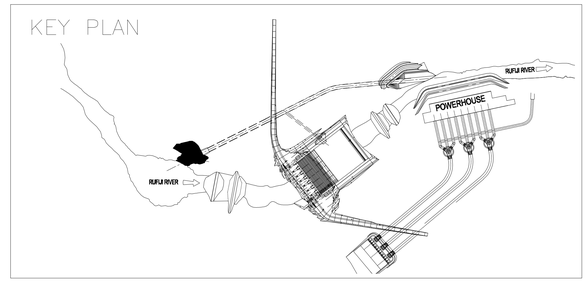
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Type: BLACK	Scale: As Shown	Size: A3
Document no. RUF-SHC300-ULX-&CTA010-000002	Rev. B	PAGE NO. 1/1

EXCAVATION PLANE OF DIVERSION TUNNEL INLET

SCALE B



KEY PLAN



NOTES:

1.THIS DRAWING IS THE EXCAVATION AND SUPPORT PLANE DRAWING OF DIVERSION TUNNEL INLET OF RUFIJI HYDROPOWER STATION.

2.THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, ROCK DOWEL AND DRAINAGEAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED.

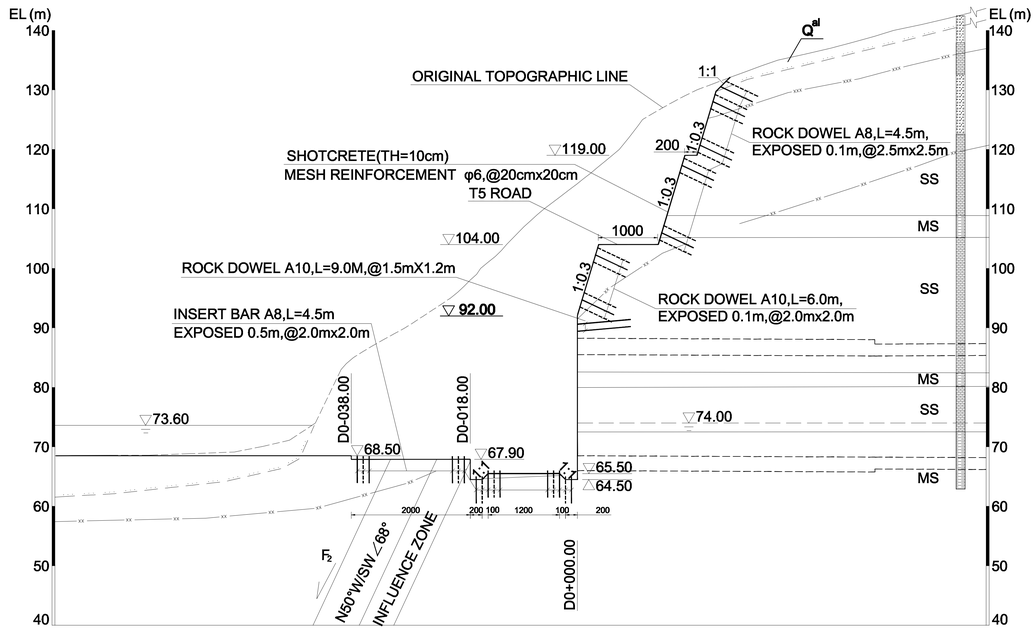
0 2.5 5.0 12.5m

GRAPHIC SCALE B 1:250

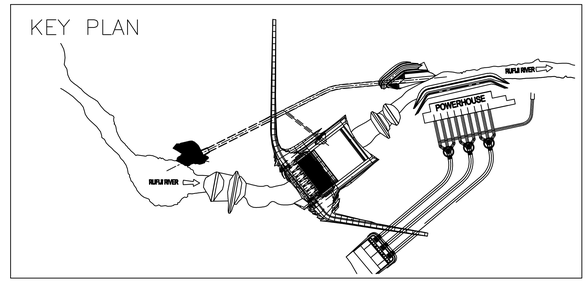
Originator The Arab Contractors OSMAN AHMAD OSMAN & CO. ELSEWEDY ELECTRIC	Title EXCAVATION OF DIVERSION TUNNEL INLET EXCAVATION PLANE OF DIVERSION TUNNEL INLET	Detail Design	Type: BLACK Scale: As Shown Size: A3 Document no. RUF-SHC310-ULX-&CTA010-001001 Rev. B PAGE NO. 1/4

LONGITUDINAL PROFILE OF DIVERSION TUNNEL INLET EXCAVATION

SCALE A



KEY PLAN



LEGEND

- FAULT DEBRIS
- FAULT BRECCIA
- Q^{al} SAND GRAVEL (ALLUVIAL)
- SS
- MS
- THE BOUNDARY BETWEEN OVERBURDEN AND BEDROCK
- STRONG-WEATHERING BOUNDARY
- MEDIUM-WEATHERING BOUNDARY
- WATER LEVEL

NOTES:

1.THIS DRAWING IS THE EXCAVATION AND SUPPORT LONGITUDINAL SECTION DRAWING OF DIVERSION TUNNEL INLET OF RUFIJI HYDROPOWER STATION,

2.THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, ROCK DOWEL AND DRAINAGEAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED.

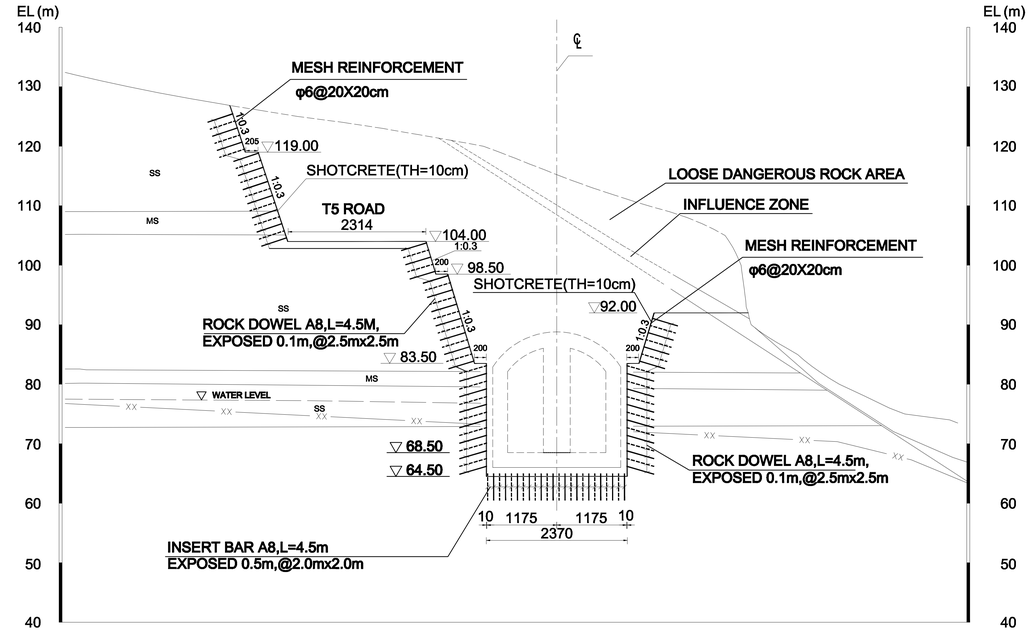
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GRAPHIC SCALE A 1:500

Originator: The Arab Contractors Osman Ahmad Osman & Co. / ELSEWEDY ELECTRIC	Title: EXCAVATION OF DIVERSION TUNNEL INLET LONGITUDINAL PROFILE OF DIVERSION TUNNEL INLET EXCAVATION	Detail Design	Type: BLACK / Scale: As Shown / Size: A3 Document no.: RUF-SHC310-ULX-&CTA010-001001 / Rev. B / PAGE NO. 2/4

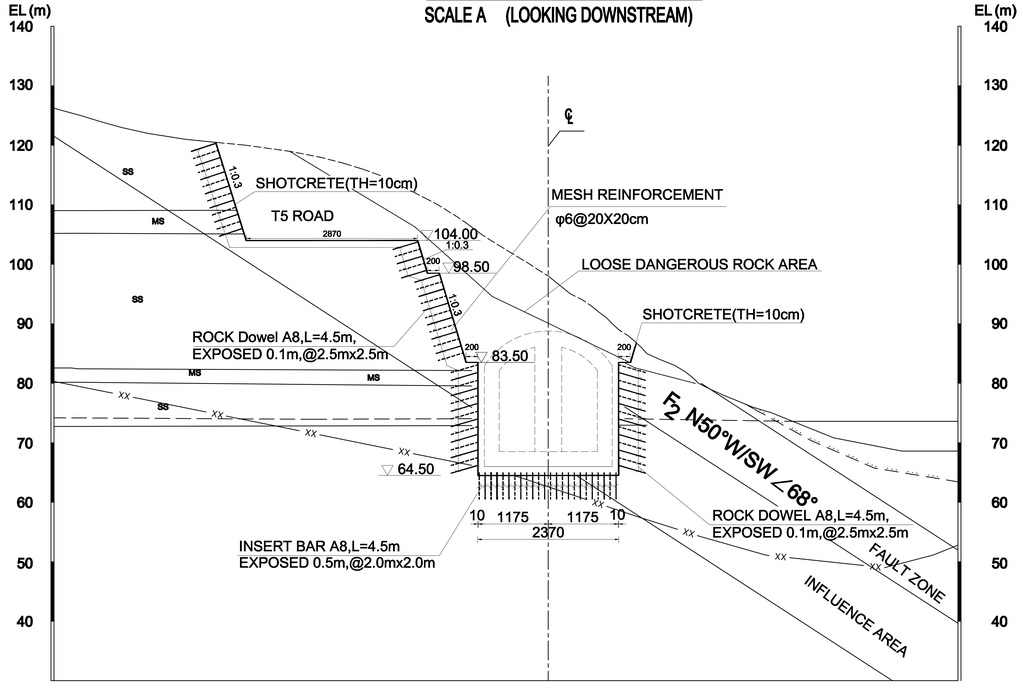
D0+000.00 PROFILE

SCALE A (LOOKING DOWNSTREAM)

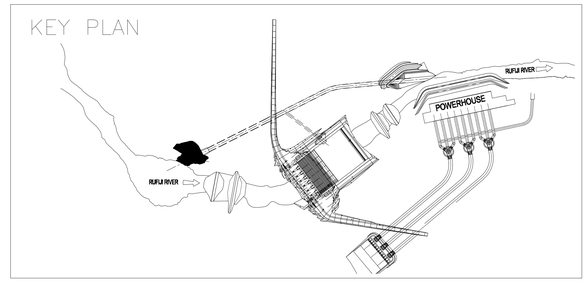


D0-018.00 PROFILE

SCALE A (LOOKING DOWNSTREAM)



KEY PLAN



LEGEND

- FAULT DEBRIS
- FAULT BRECCIA
- SS
- MS
- WATER LEVEL
- MEDIUM-WEATHERING BOUNDARY
- THE BOUNDARY BETWEEN OVERBURDEN AND BEDROCK

NOTES:

1.THIS DRAWING IS THE EXCAVATION AND SUPPORT CROSS SECTION DRAWING OF DIVERSION TUNNEL INLET OF RUFIJI HYDROPOWER STATION.

2.THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, ROCK DOWEL AND DRAINAGEAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED.

0 5 10 25m

GRAPHIC SCALE A 1:500

Originator

The Arab Contractors OSMAN AHMAD OSMAN & CO.

ELSEWEDY ELECTRIC

Detail Design

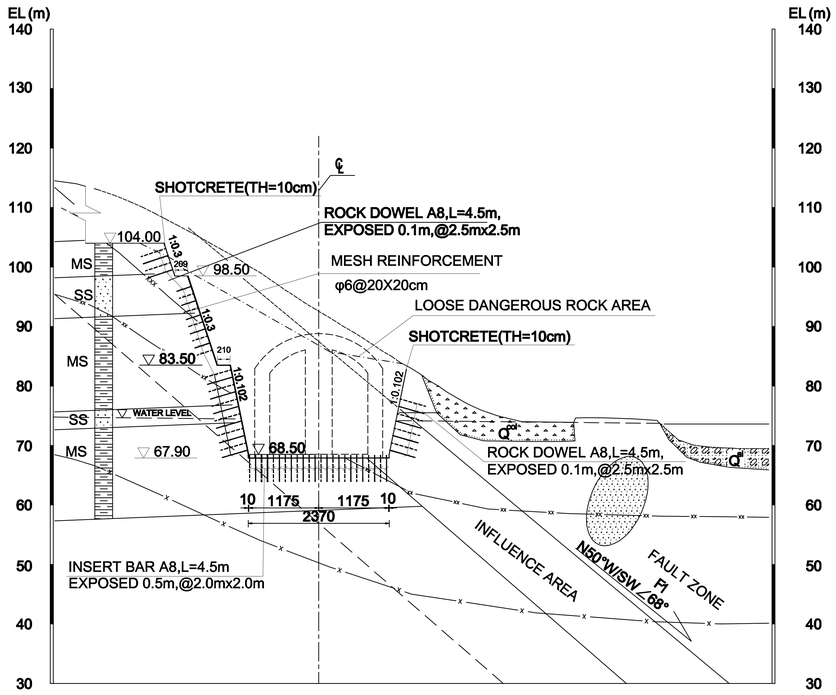
EXCAVATION OF DIVERSION TUNNEL INLET

CROSS SECTION OF DIVERSION TUNNEL INLET EXCAVATION

Type: BLACK	Scale: As Shown	Size: A3
Document no. RUF-SHC310-ULX-&CTA010-001001	Rev. B	PAGE NO. 3/4

D0-025.00 PROFILE

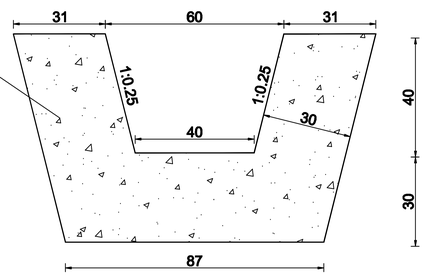
SCALE A (LOOKING DOWNSTREAM)

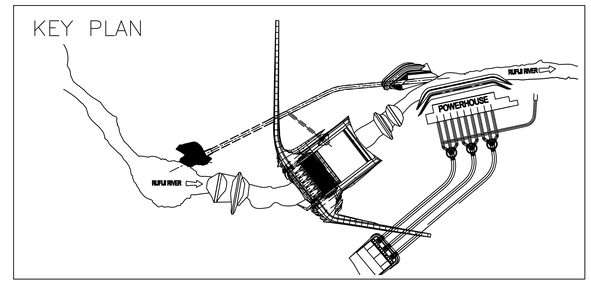


DETAIL DRAWING OF INTERCEPTING DITCH

SCALE C

CONCRETE C10





LEGEND

- FAULT DEBRIS
- FAULT BRECCIA
- Q^{col} RUBBLES ANA ANGULAR CODDLES (COLLAPSE)
- Q^{al} SAND GRAVEL (ALLUVIAL)
- SS
- MS
- THE BOUNDARY BETWEEN OVERBURDEN AND BEDROCK
- MEDIUM-WEATHERING BOUNDARY
- WEAK—WEATHERING BOUNDARY
- WATER LEVEL
- STRONG— UNLOADING BOUNDARY

0 5 10 25m

GRAPHIC SCALE A 1:500

0 0,1 0,2 0.5m

GRAPHIC SCALE C 1:10

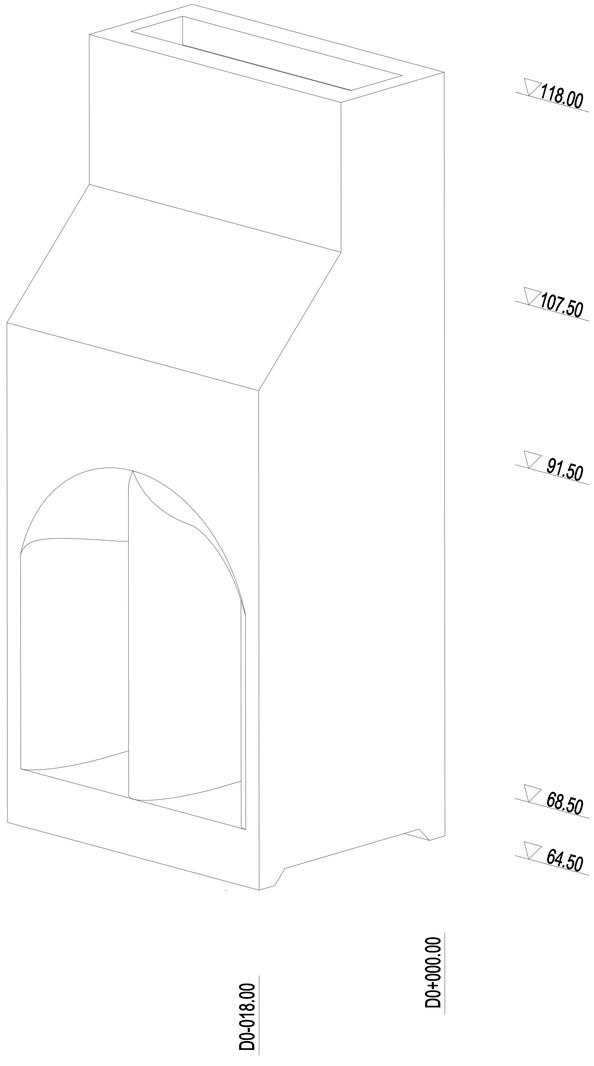
NOTES:

1.THIS DRAWING IS THE EXCAVATION AND SUPPORT CROSS SECTION DRAWING OF DIVERSION TUNNEL INLET OF RUFIJI HYDROPOWER STATION.

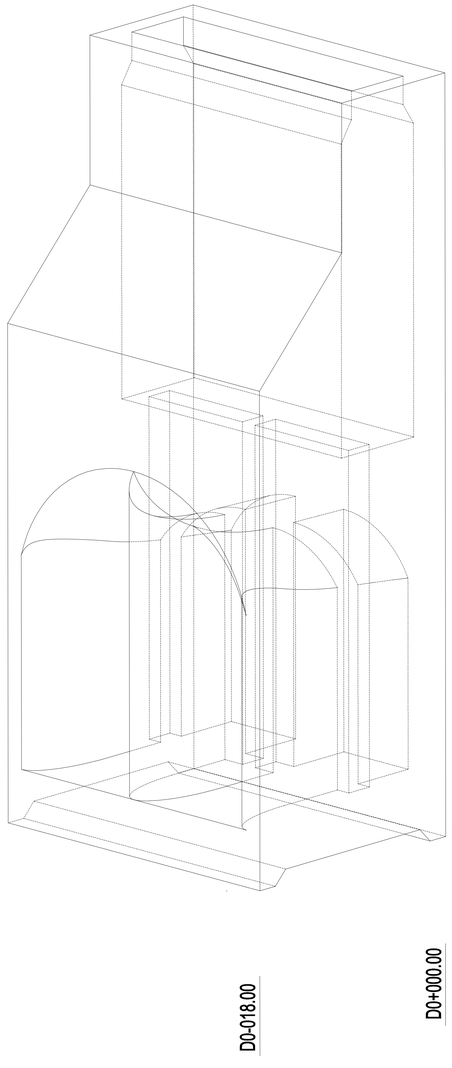
2.THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, ROCK DOWEL AND DRAINAGEAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED.

Originator: The Arab Contractors Osman Ahmad Osman & Co. / Elsewedy Electric	Title: EXCAVATION OF DIVERSION TUNNEL INLET CROSS SECTION OF DIVERSION TUNNEL INLET EXCAVATION	Detail Design	Type: BLACK / Scale: As Shown / Size: A3 Document no.: RUF-SHC310-ULX-&CTA010-001001 / Rev. B / PAGE NO. 4/4

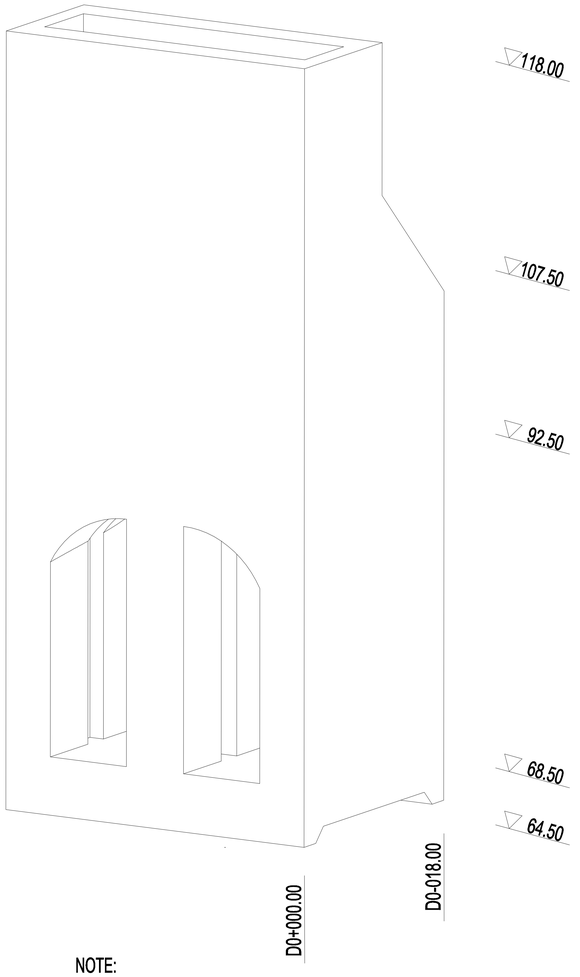
ISOMETRIC VIEW



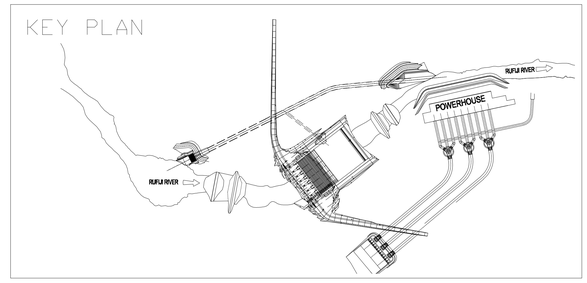
SCENOGRAPH



ISOMETRIC VIEW



KEY PLAN



NOTE:

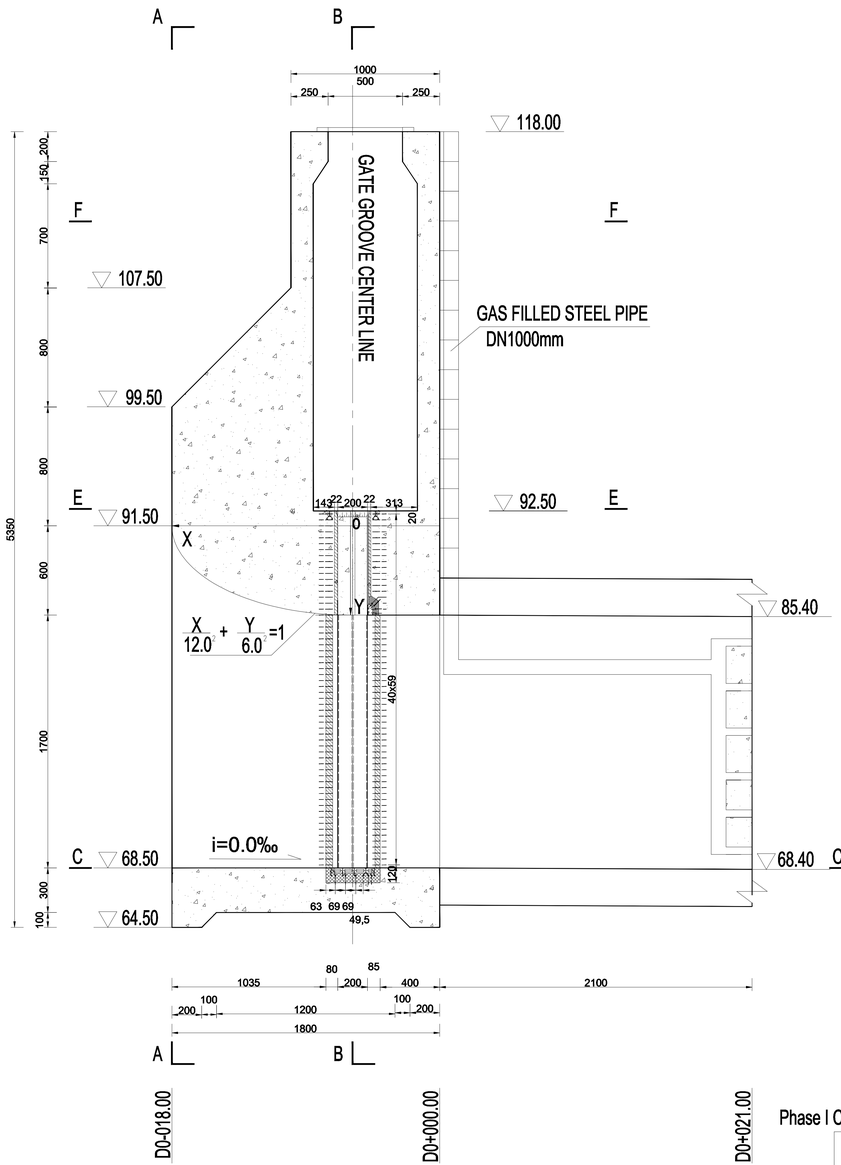
1、THE DRAWING IS THE ENTRANCE GATE SHAFT STRUCTURE AND REINFORCEMENT OF DIVERSION TUNNEL. THIS DRAWING IS THE FIRST ONE.

2、THE ELEVATIONS AND CHAINAGES ARE MARKED IN M.

Originator The Arab Contractors Osman Ahmad Osman & Co. / Elsewedy Electric	Title: GATE SHAFT OF DIVERSION TUNNEL STRUCTURAL ISOMETRIC DRAWING	Detail Design	Type: BLACK / Scale: As Shown / Size: A3
		Document no. RUF-SHC320-ULX-&CTA010-001001	Rev. B / PAGE NO. 1/6

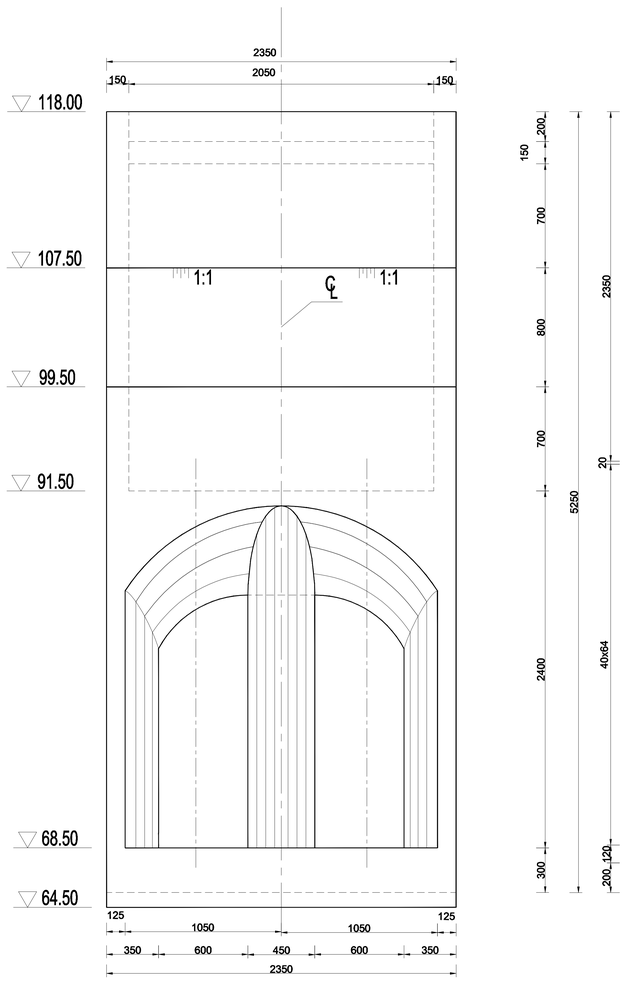
GATE SHAFT SECTIONAL VIEW

SCALE A



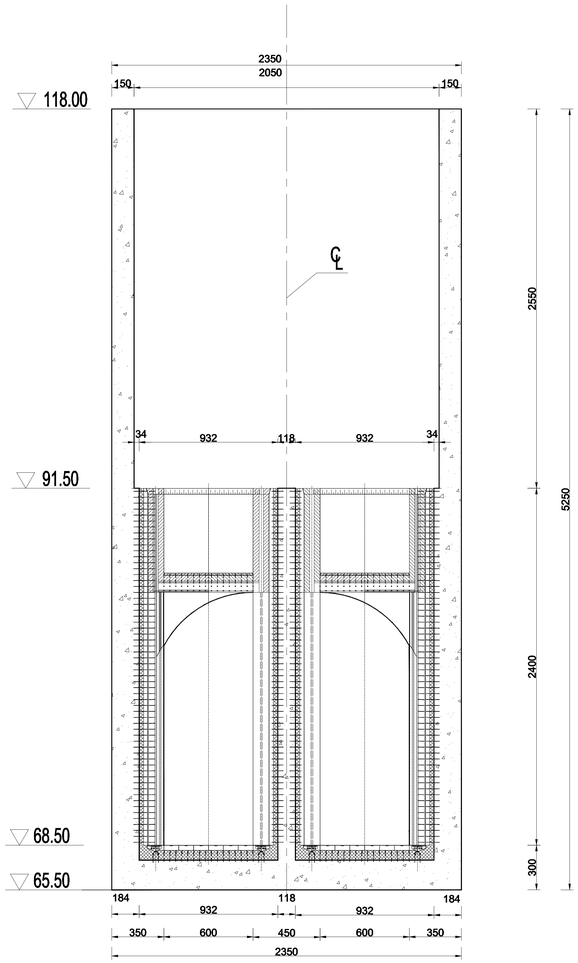
A-A CUTAWAY VIEW

SCALE A



B-B CUTAWAY VIEW

SCALE A



Legend

Phase I Concrete Surface | Phase I Concrete Profile | Phase II Concrete Surface | Phase II Concrete Profile

NOTE:

1.THE DRAWING IS THE IMPORT STRUCTURE OF DIVERSION TUNNEL OF RUFIJI HYDROPOWER STATION.
2.THE ELEVATIONS AND CHAINAGES ARE MARKED IN M.OTHER DIMENSIONS ARE MARKED IN CM.

0 2 4 10m

GRAPHIC SCALE A 1:200

Originator

The Arab Contractors — Osman Ahmad Osman & Co.

ELSEWEDY ELECTRIC

Title

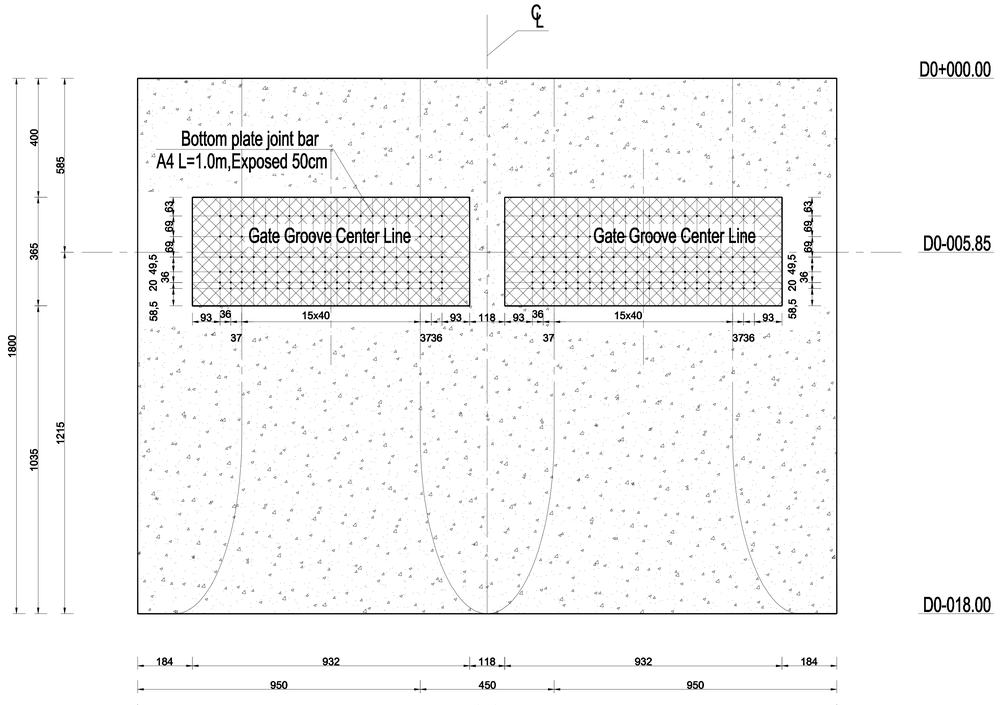
GATE SHAFT OF DIVERSION TUNNEL
STRUCTURAL PROFILE DRAWING

Detail Design

Type: BLACK	Scale: As Shown	Size: A3
Document no. RUF-SHC320-ULX-&CTA010-001001	Rev. B	PAGE NO. 2/6

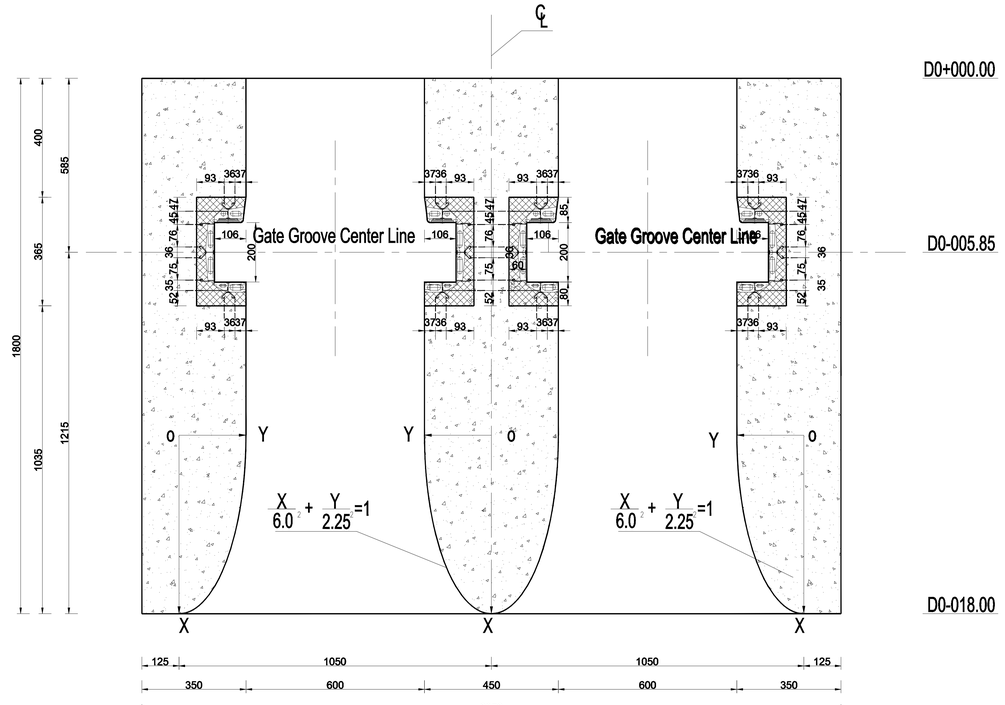
C-C CROSS-SECTION

SCALE A



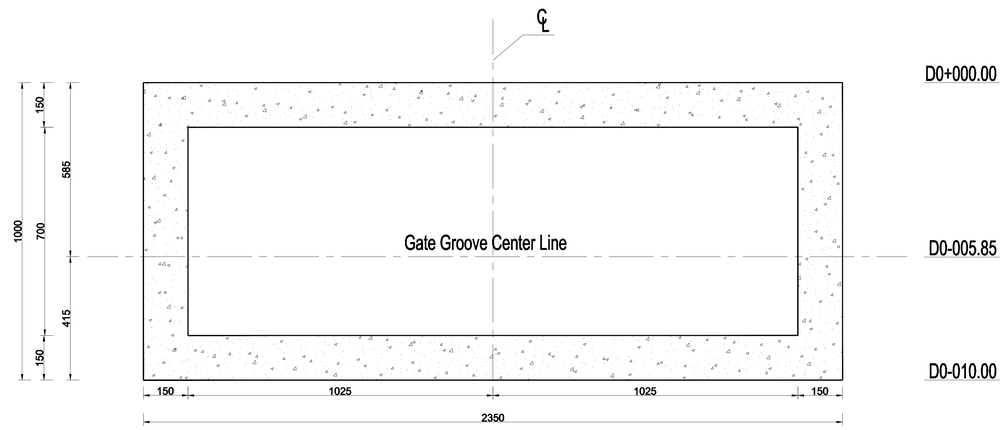
D-D CROSS-SECTION

SCALE A



F-F CROSS-SECTION

SCALE A



Legend

Phase I Concrete Surface | Phase I Concrete Profile | Phase II Concrete Surface | Phase II Concrete Profile

NOTE:

1、THE DRAWING IS THE ENTRANCE GATE SHAFT STRUCTURE AND REINFORCEMENT OF DIVERSION TUNNEL. THIS DRAWING IS THE THIRD .

2、THE ELEVATIONS AND CHAINAGES ARE MARKED IN M.OTHER DIMENSIONS ARE MARKED IN CM

0 2 4 10m

GRAPHIC SCALE A 1:200

Originator

The Arab Contractors — Osman Ahmad Osman & Co. — المقاولون العرب — عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

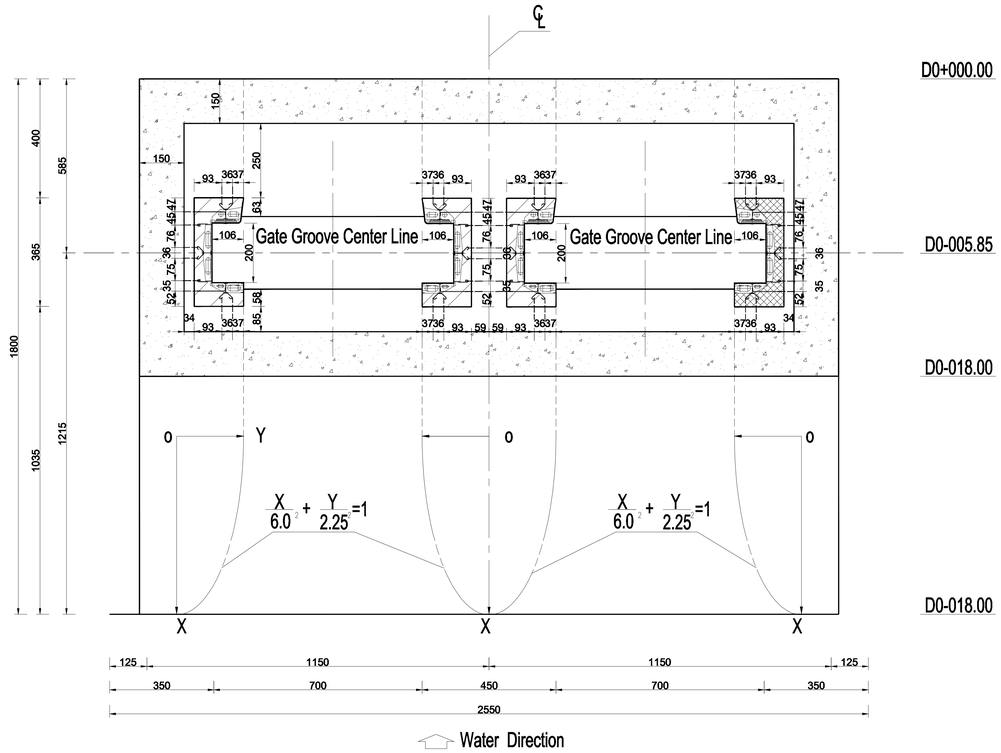
GATE SHAFT OF DIVERSION TUNNEL
STRUCTURAL PROFILE DRAWING

Detail Design

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Document no. RUF-SHC410-ULZ-&CTA010-001001	Rev. B	PAGE NO. 3/6

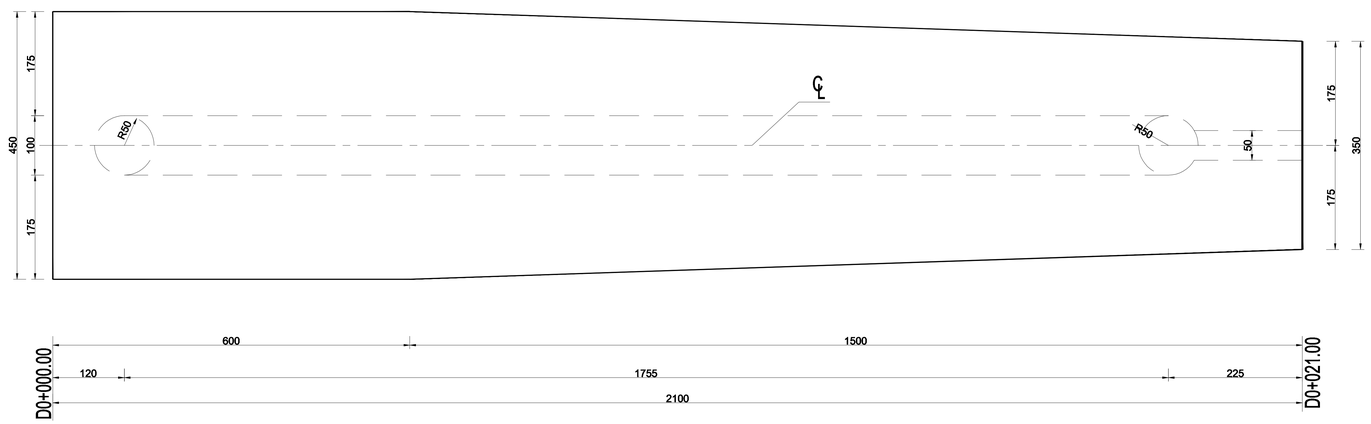
E-E CROSS-SECTION

SCALE A



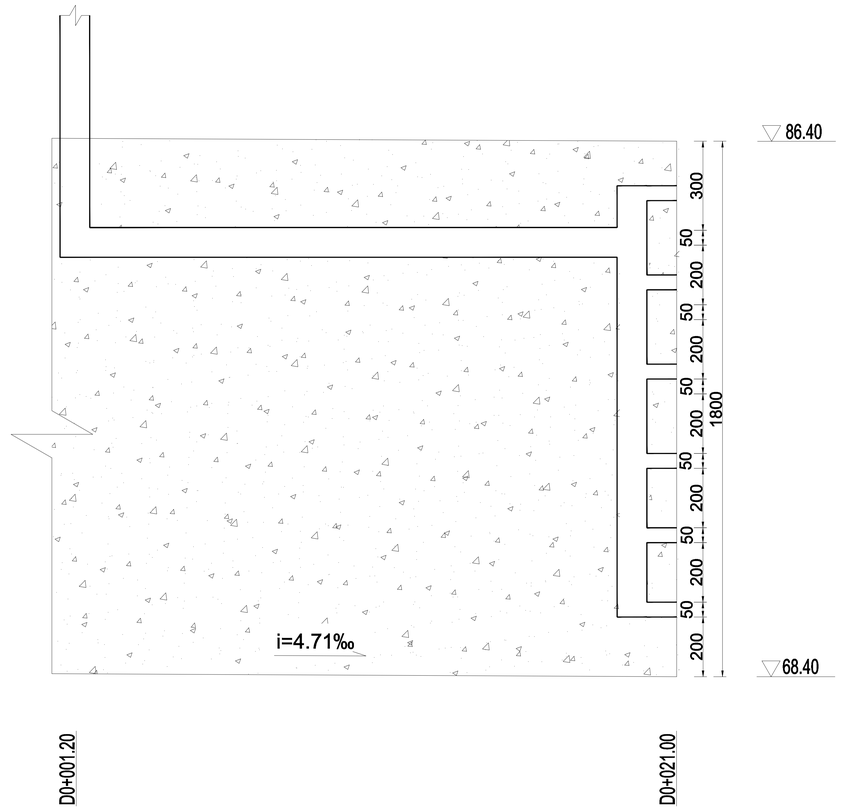
PLANE LAYOUT OF EXHAUST HOLES

SCALE A



EXHAUST HOLE PROFILE

SCALE A



Legend

Phase I Concrete Surface | Phase I Concrete Profile | Phase II Concrete Surface | Phase II Concrete Profile

NOTE:

1、THE DRAWING IS THE ENTRANCE GATE SHAFT STRUCTURE AND REINFORCEMENT OF DIVERSION TUNNEL. THIS DRAWING IS THE FOURTH.

2、THE ELEVATIONS AND CHAINAGES ARE MARKED IN M.OTHER DIMENSIONS ARE MARKED IN CM

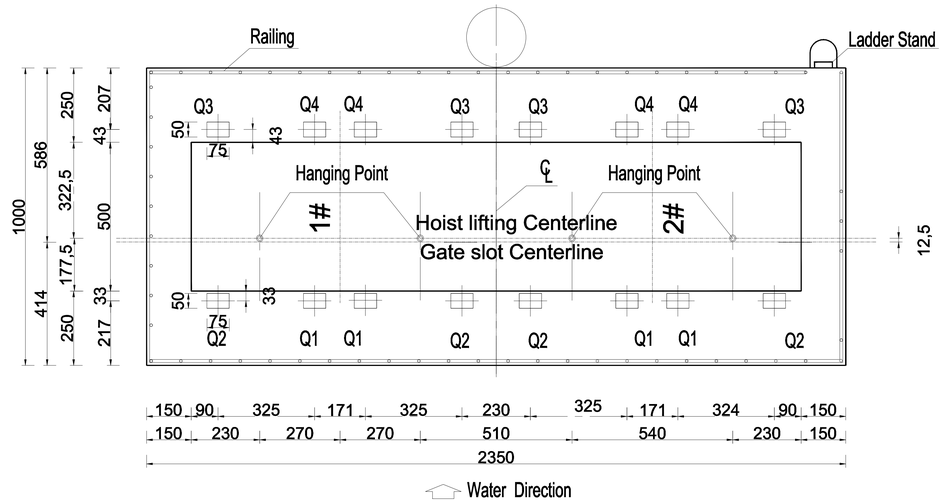
0 2 4 10m

GRAPHIC SCALE A 1:200

Originator	Title	Detail Design	
The Arab Contractors Osman Ahmad Osman & Co. / ELSEWEDY ELECTRIC	GATE SHAFT OF DIVERSION TUNNEL EXHAUST HOLE PROFILE	Type: BLACK	Scale: As Shown / Size: A3
		Document no.: RUF-SHC320-ULX-&CTA010-001001	Rev. B / PAGE NO. 4/6

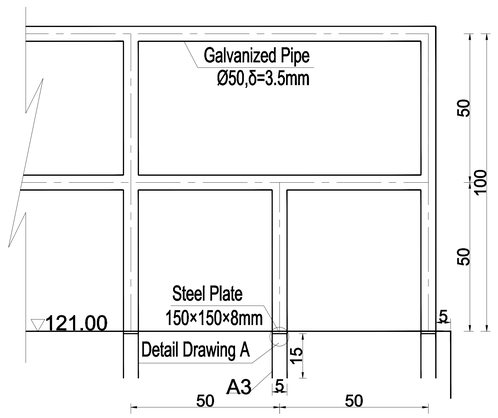
118M EL LAYOUT

SCALE A



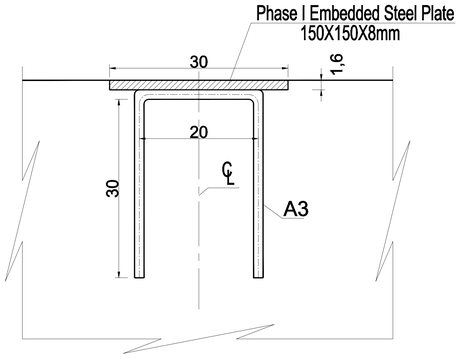
LAYOUT OF RAILINGS AND BURIED PARTS

SCALE B



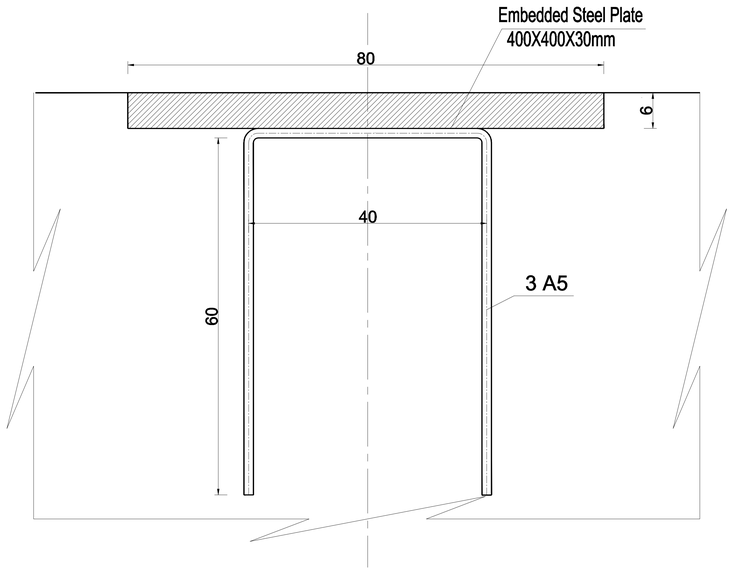
DETAIL DRAWING A

SCALE D



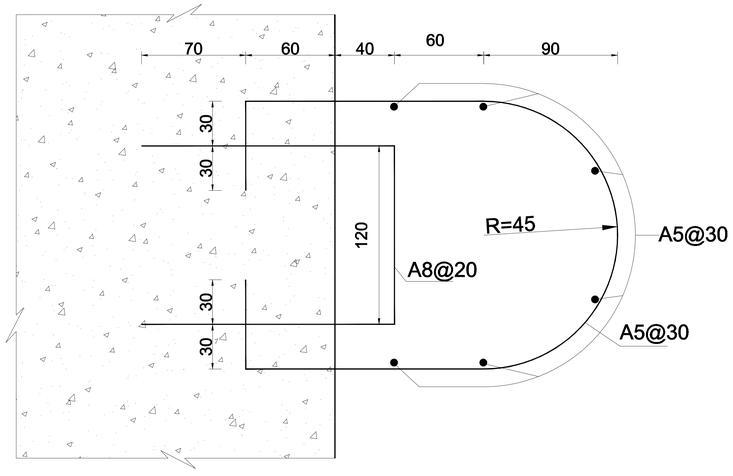
EMBEDDED STEEL PLATE FOR HOIST FOUNDATION

SCALE D



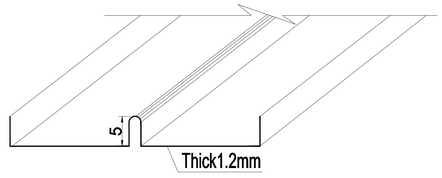
LAYOUT OF RAILINGS AND BURIED PARTS

SCALE C



WATER STOPPING COPPER

SCALE D



0 2 4 10m
GRAPHIC SCALE A 1:200

0 0.1 0.2 0.5m
GRAPHIC SCALE B 1:10

0 0.2 0.4 1.0m
GRAPHIC SCALE C 1:20

0 0.005 0.01 0.025m
GRAPHIC SCALE D 1:0.5

Originator

The Arab Contractors Osman Ahmad Osman & Co.
المقاولون العرب
عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

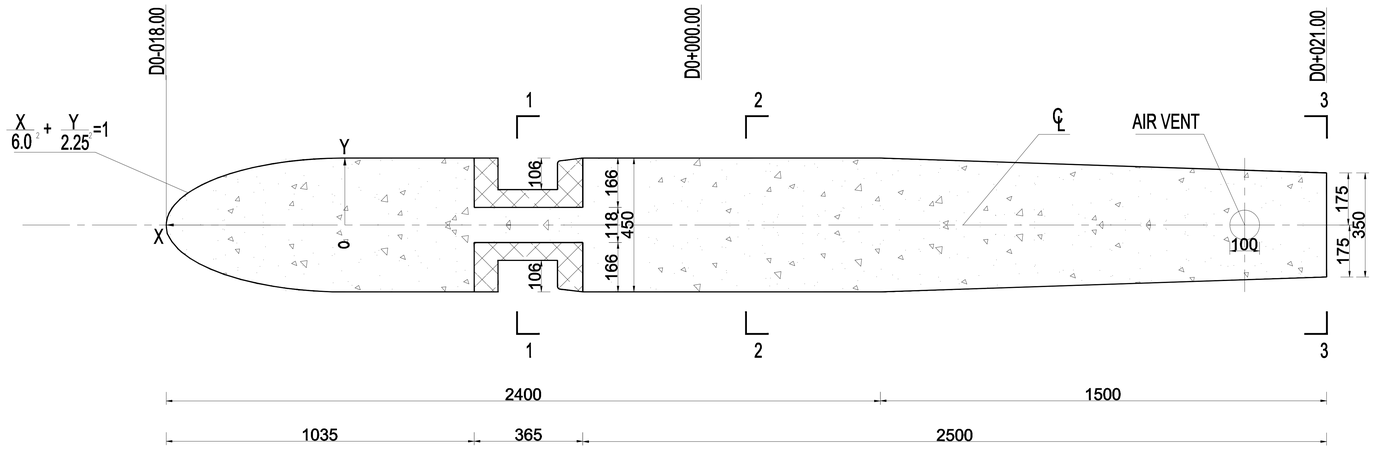
GATE SHAFT OF DIVERSION TUNNEL
TOP DETAIL STRUCTURE

Detail Design

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Document no. RUF-SHC320-ULX-&CTA010-001001	Rev. B	PAGE NO. 5/6

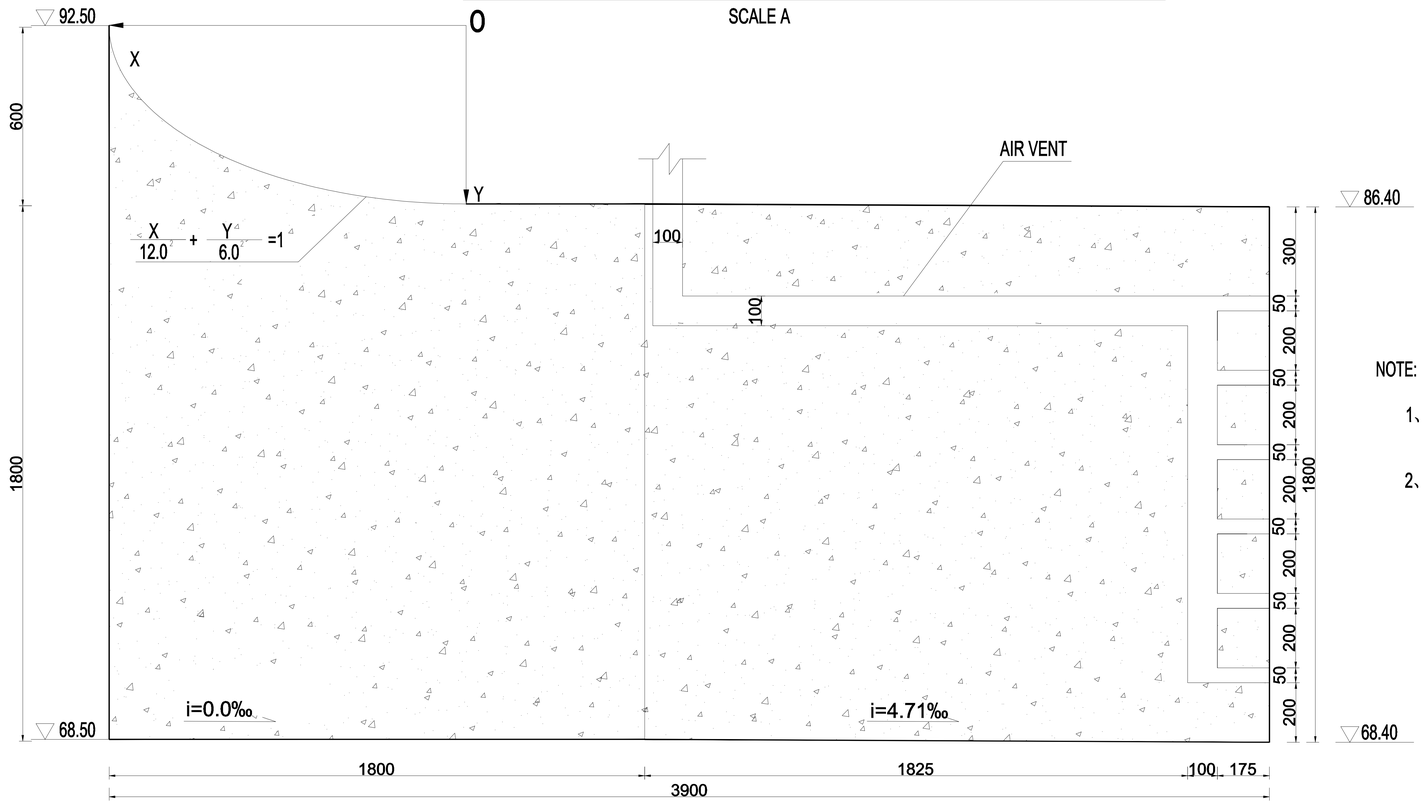
MIDDLE PIER PLAN

SCALE A



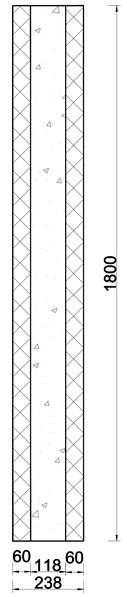
LONGITUDINAL PROFILE OF MIDDLE PIER

SCALE A



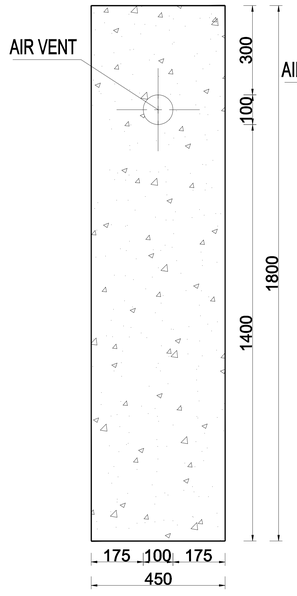
1-1

SCALE A



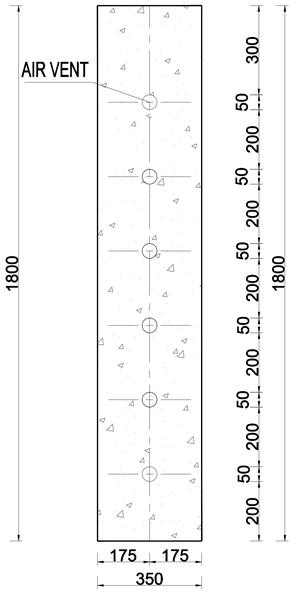
2-2

SCALE A



3-3

SCALE A



Legend

Phase I Concrete Surface | Phase I Concrete Profile | Phase II Concrete Surface | Phase II Concrete Profile

NOTE:

1、THE DRAWING IS THE ENTRANCE GATE SHAFT STRUCTURE AND REINFORCEMENT OF DIVERSION TUNNEL. THIS DRAWING IS THE SIXTH .

2、THE ELEVATIONS AND CHAINAGES ARE MARKED IN M.OTHER DIMENSIONS ARE MARKED IN CM.

0 2 4 10m

GRAPHIC SCALE A 1:200

Originator

The Arab Contractors OSMAN AHMAD OSMAN & CO.

ELSEWEDY ELECTRIC

Title

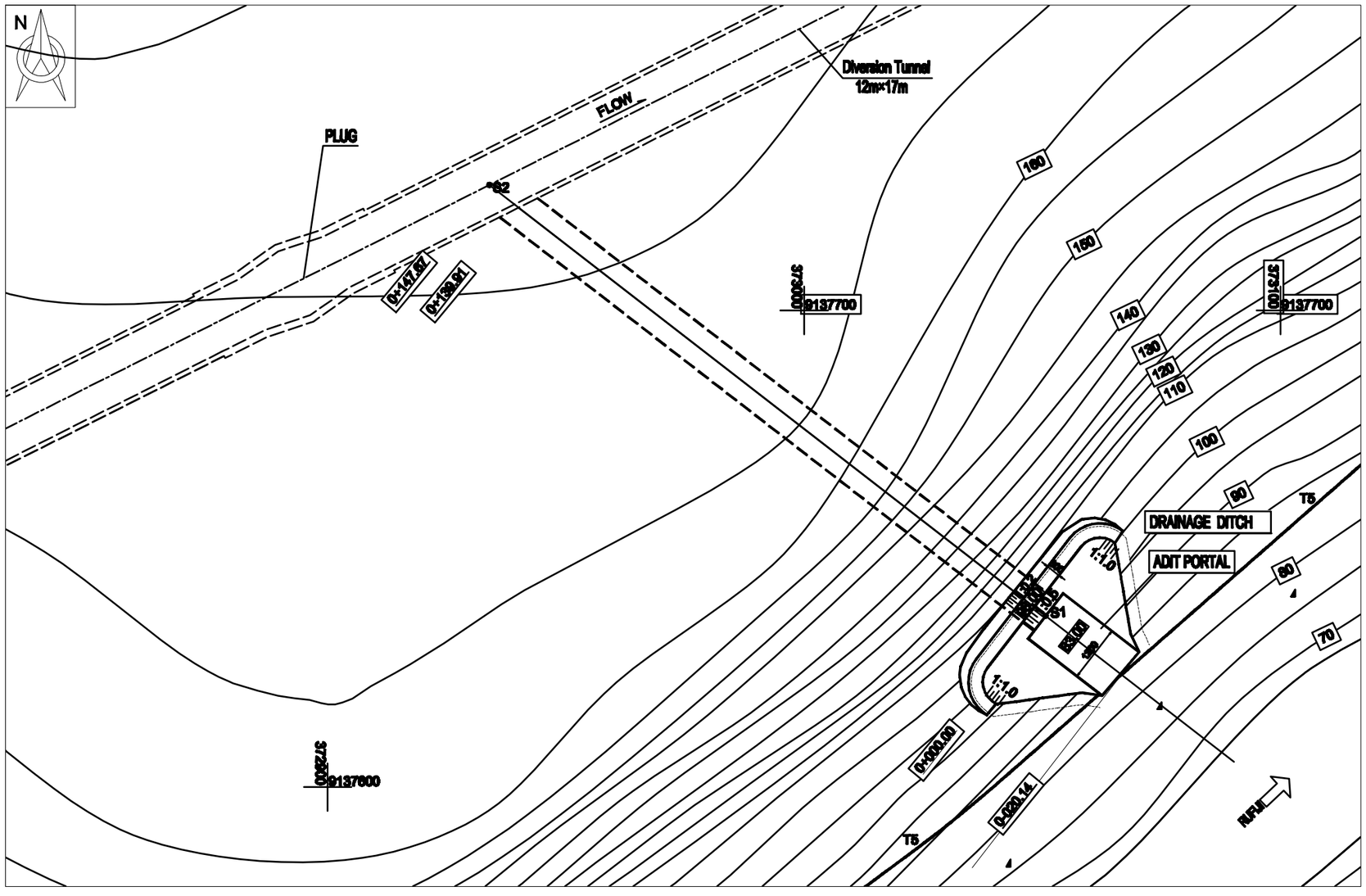
GATE SHAFT OF DIVERSION TUNNEL
MIDDLE PIER

Detail Design

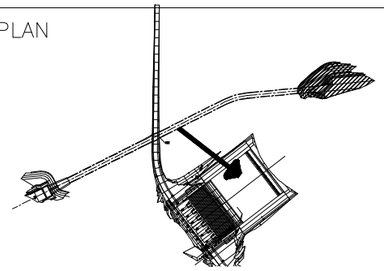
Type: BLACK	Scale: As Shown	Size: A3
Document no. RUF-SHC320-ULX-&CTA010-001001	Rev. B	PAGE NO. 6/6

LAYOUT PLAN OF DIVERSION TUNNEL ADIT

SCALE A



KEY PLAN



Notes:

1. This set of drawings is the construction drawings of adit of Rufiji Hydropower Station Project, 3 in total, this is the 1st;
2. The dimensions in this drawing are all in cm except for elevation, coordinates and Mileage measured in m and steel bar diameter, drain hole diameter in mm;
3. If necessary, Concentrated seepage point should set drain hole, Drain hole diameter 50, length 3.0 m, elevation 10 degrees should be set in the Shotcrete part;
4. The supporting methods of the adit portal excavation slope are as follows :
   Rock dowel A8,L=4.5m,@3mx3m;
   shotcrete CY15,(Th=0.1~0.2m);
   Mesh reinforcement C3,@0.2mx0.2m.

CONTROL POINT COORDINATES

Num	Coordinates	
	X Coordinate(m)	Y Coordinate(m)
S1	9137635.9229	373050.6982
S2	9137726.3237	372933.9351

0 5 10 25m

GRAPHIC SCALE A 1:500

Originator

The Arab Contractors — ELSEWEDY ELECTRIC

Title: ADIT — LAYOUT PLAN OF DIVERSION TUNNEL ADIT

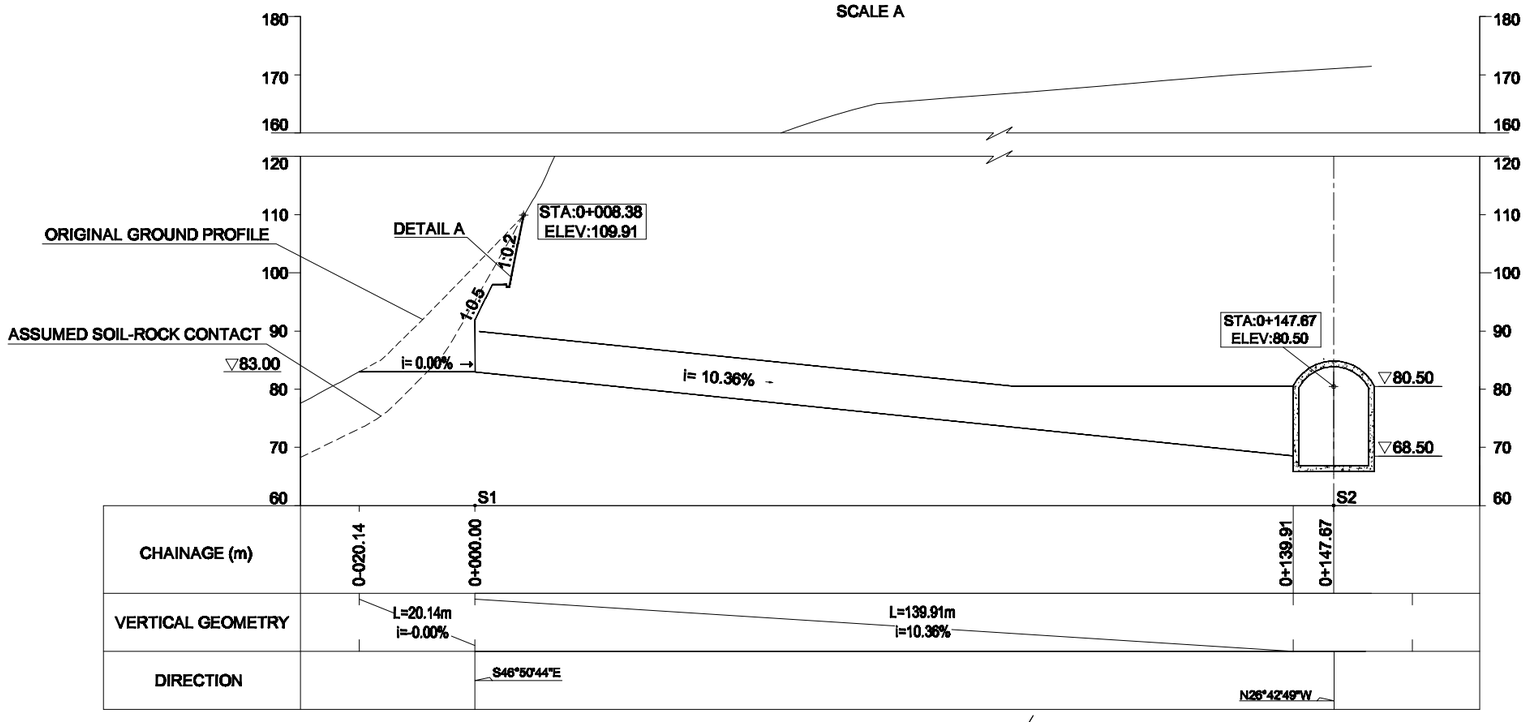
Detail Design

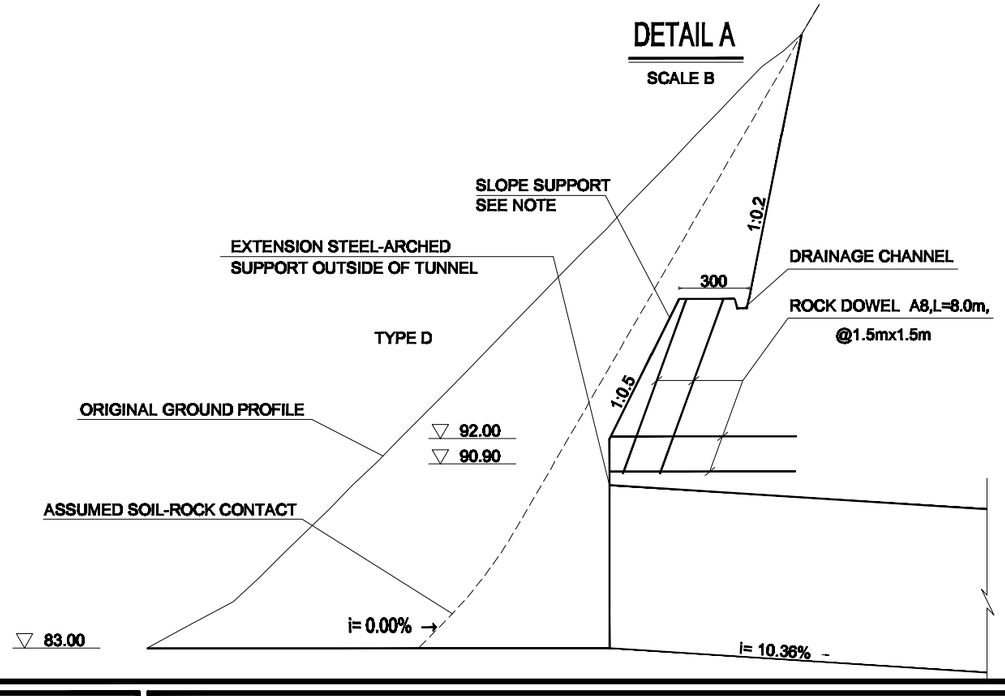
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Document no.: RUF-SHC350-ULX-&CTA010-001001 | Rev. B | PAGE NO. 1/3

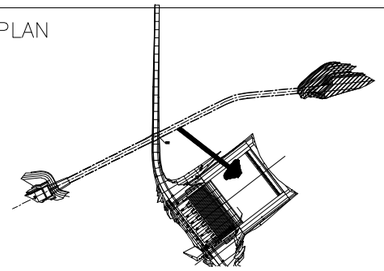
L-PROFILE OF ADIT

SCALE A





KEY PLAN



Notes:

1. This set of drawings is the construction drawings of adit of Rufiji Hydropower Station Project, 3 in total,this is the 2nd;
2. The dimensions in this drawing are all in cm except for elevation, coordinates and Mileage measured in m and steel bar diameter, drain hole diameter in mm;
3. If necessary ,Concentrated seepage point should set drain hole,Drain hole diameter 50, length 3.0 m, elevation 10 degrees should be set in the Shotcrete part;
4. The supporting methods of the adit portal excavation slope are as follows :

   Rock dowel A8,L=4.5m,@3mx3m;
   shotcrete CY15,(Th=0.1~0.2m);
   Mesh reinforcement C3,@0.2mx0.2m.

0 5 10 25m
GRAPHIC SCALE A 1:500

0 1.25 2.50 6.25m
GRAPHIC SCALE B 1:125

Originator

The Arab Contractors
ELSEWEDY ELECTRIC

Title

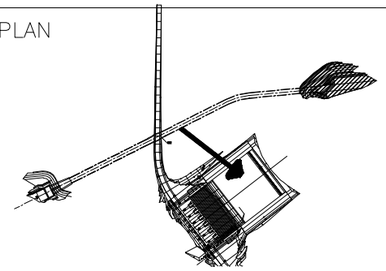
Detail Design

ADIT

L-PROFILE OF ADIT

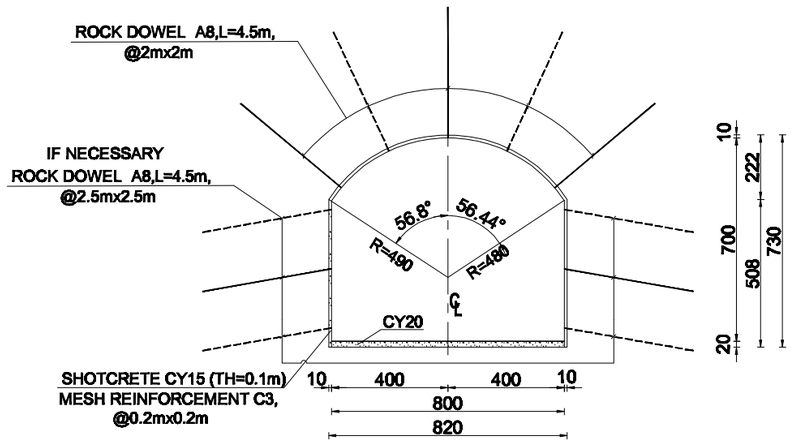
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KEY PLAN



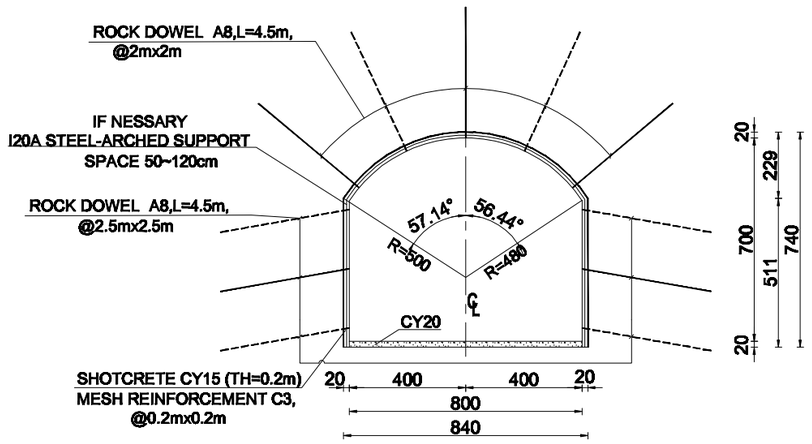
TYPE A PROFILE
SCALE C

(Ⅲ TYPE SURROUNDING ROCKS)



TYPE B PROFILE
SCALE C

(Ⅳ TYPE SURROUNDING ROCKS)





GRAPHIC SCALE C 1:100

Notes:

1. This set of drawings is the construction drawings of adit of Rufiji Hydropower Station Project, 3 in total,this is the 3nd;
2. The dimensions in this drawing are all in cm except for elevation, coordinates and Mileage measured in m and steel bar diameter, drain hole diameter in mm;
3. If necessary ,Concentrated seepage point should set drain hole,Drain hole diameter 50, length 3.0 m, elevation 10 degrees should be set in the Shotcrete part;
4. Type A section is the supporting methods for ⅢTYPE surrounding rocks,Type B section is the supporting methods for ⅣTYPE surrounding rocks, Ⅴ TYPE surrounding rocks supporting methods needs to be determined according to the site geological conditions.
5. The supporting methods of the adit portal excavation slope are as follows :

   Rock dowel A8,L=4.5m,@3mx3m;
   shotcrete CY15,(Th=0.1~0.2m);
   Mesh reinforcement C3,@0.2mx0.2m.

Originator

The Arab Contractors
ELSEWEDY ELECTRIC

Title

Detail Design

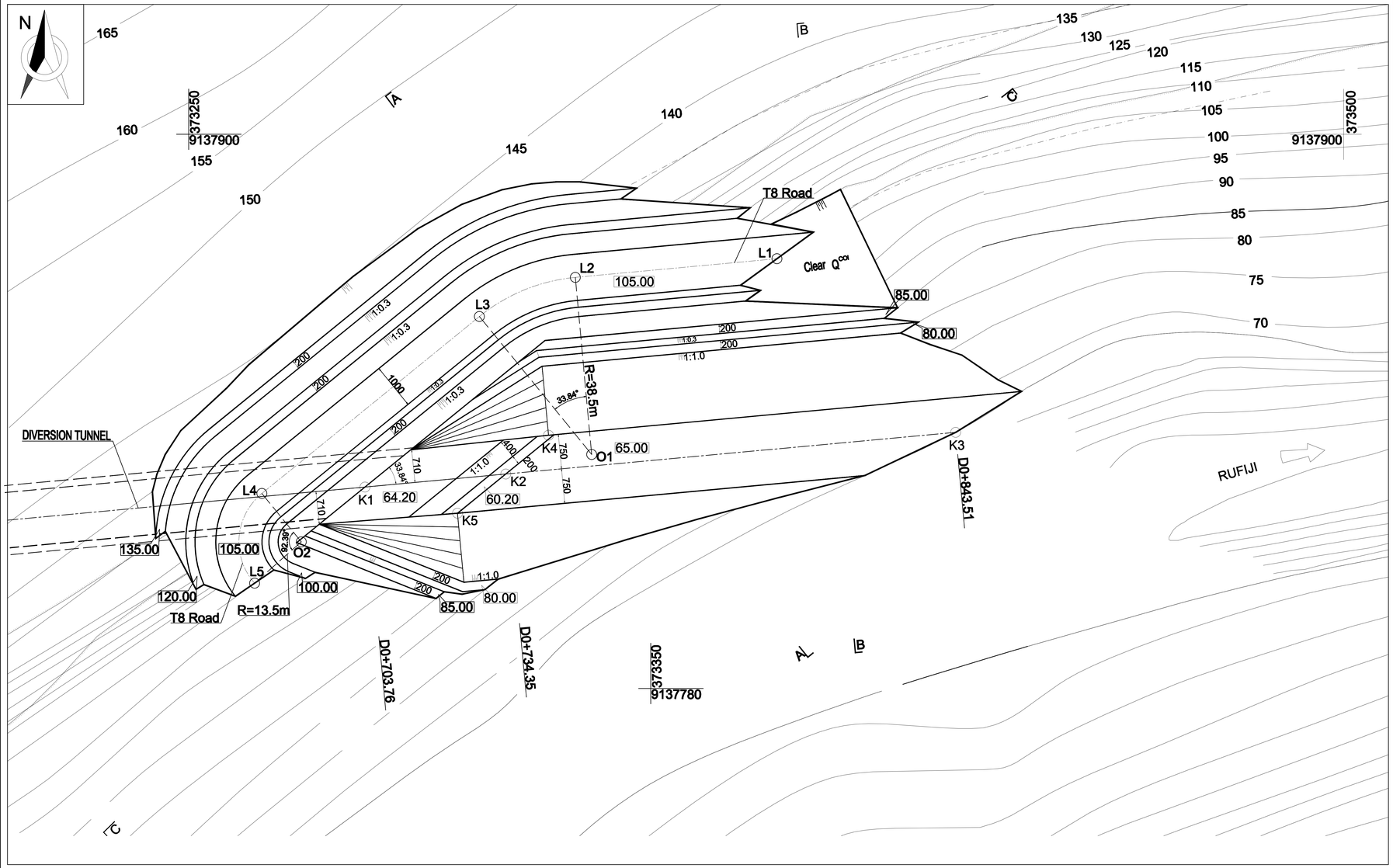
ADIT

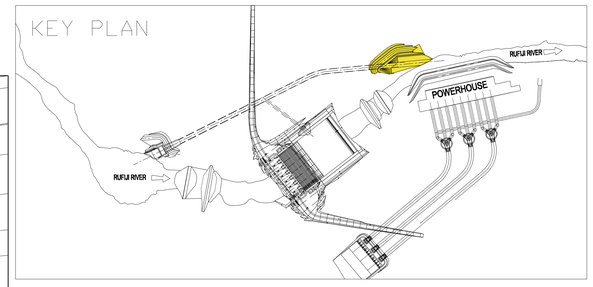
TYPICAL PROFILE SUPPORT

Type: BLACK	Scale: As Shown	Size: A3
Document no. RUF-SHC350-ULX-&CTA010-001001	Rev. B	PAGE NO. 3/3

EXCAVATION PLANE OF DIVERSION TUNNEL OUTLET

SCALE A





LEGEND

THE BOUNDARY BETWEEN OVERBURDEN AND BEDROCK

STRONG— UNLOADING BOUNDARY

Notes:

1. This set of drawings is the excavation drawing of diversion tunnel exit of Rufiji Hydropower Station Project, 4 in total,this is the 1st;
2. The dimensions in this drawing are all in cm except for elevation, coordinates and Mileage measured in m and steel bar diameter, drain hole diameter in mm;
3. It is required to reserve 1.5m protective layer above the foundation surface in construction. Blasting parameters should be strictly controlled in the excavation of protective layer;
4. See other drawings for details of diversion tunnel entry and exit structures, open channel structures, entrance and excavation support of tunnel section;
5. Drain hole diameter 50, plum blossom layout, row spacing 3.0 mx3.0 m, length 3.0 m, elevation 10 degrees should be set in the Shotcrete part;
6. Before excavating the OUTLET of diversion tunnel, it is necessary to clean up the upper loose rock mass

COORDINATE LIST

Num	Coordinates		Num	Coordinates	
	X Coordinate(m)	Y Coordinate(m)		X Coordinate(m)	Y Coordinate(m)
K1	9137823.6174	373288.1556	L1	9137873.0548	373377.3242
K2	9137826.4402	373318.6216	L2	9137869.0109	373333.6776
K3	9137835.4624	373415.9993	L3	9137860.5372	373312.9293
K4	9137834.8304	373327.8822	L4	9137822.2213	373265.8434
K5	9137817.9402	373308.1762	L5	9137802.7993	373264.2582
O1	9137830.6751	373337.2295	O2	9137811.7501	373274.3642

0 5 10 25m

GRAPHIC SCALE A 1:500

Originator

The Arab Contractors OSMAN AHMAD OSMAN & CO.

ELSEWEDY ELECTRIC

Title

EXCAVATION OF DIVERSION TUNNEL OUTLET

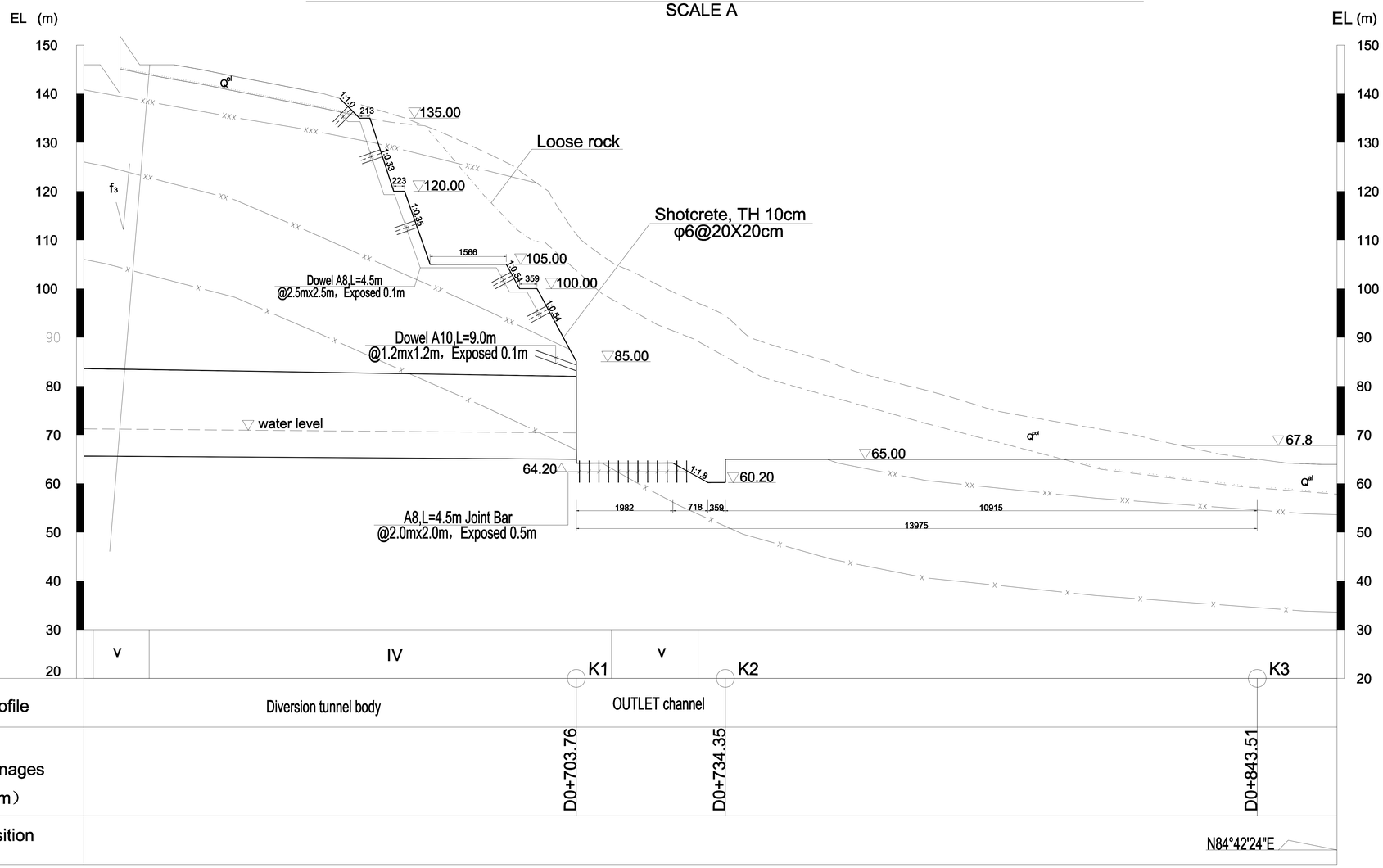
EXCAVATION PLANE FOR DIVERSION TUNNEL OUTLET

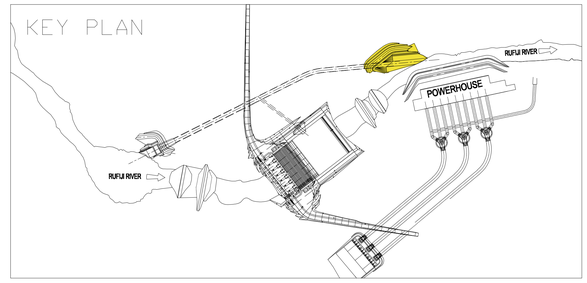
Detail Design

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Document no. RUF-SHC360-ULX-&CTA010-001001	Rev. B	PAGE NO. 1/4

LONGITUDINAL PROFILE OF DIVERSION TUNNEL OUTLET EXCAVATION

SCALE A





LEGEND

- FAULT DEBRIS
- Q^{col} RUBBLES ANA ANGULAR CODDLES (COLLAPSE)
- Q^{al} SAND GRAVEL (ALLUVIAL)
- SS
- MS
- Q^{el} SILTY CLAY (RESIDUAL)
- FAULT BRECCIA
- THE BOUNDARY BETWEEN OVERBURDEN AND BEDROCK
- STRONG-WEATHERING BOUNDARY
- WEAK—WEATHERING BOUNDARY
- WATER LEVEL
- STRONG— UNLOADING BOUNDARY
- MEDIUM-WEATHERING BOUNDARY

Notes：

1.This set of drawings is the excavation drawing of diversion tunnel exit of Rufiji Hydropower Station Project, 4 in total,this is the 2st；

2.The dimensions in this drawing are all in cm except for elevation measured in m and steel bar diameter, drain hole diameter in mm；

3. Drain hole diameter 50, plum blossom layout, row spacing 3.0 mx3.0 m, length 3.0 m, elevation 10 degrees should be set in the Shotcrete part；

4. Before excavating the OUTLET of diversion tunnel, it is necessary to clean up the upper loose rock mass.

0 5 10 25m

GRAPHIC SCALE A 1:500

Originator

The Arab Contractors OSMAN AHMAD OSMAN & CO. المقاولون العرب عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

EXCAVATION OF DIVERSION TUNNEL OUTLET

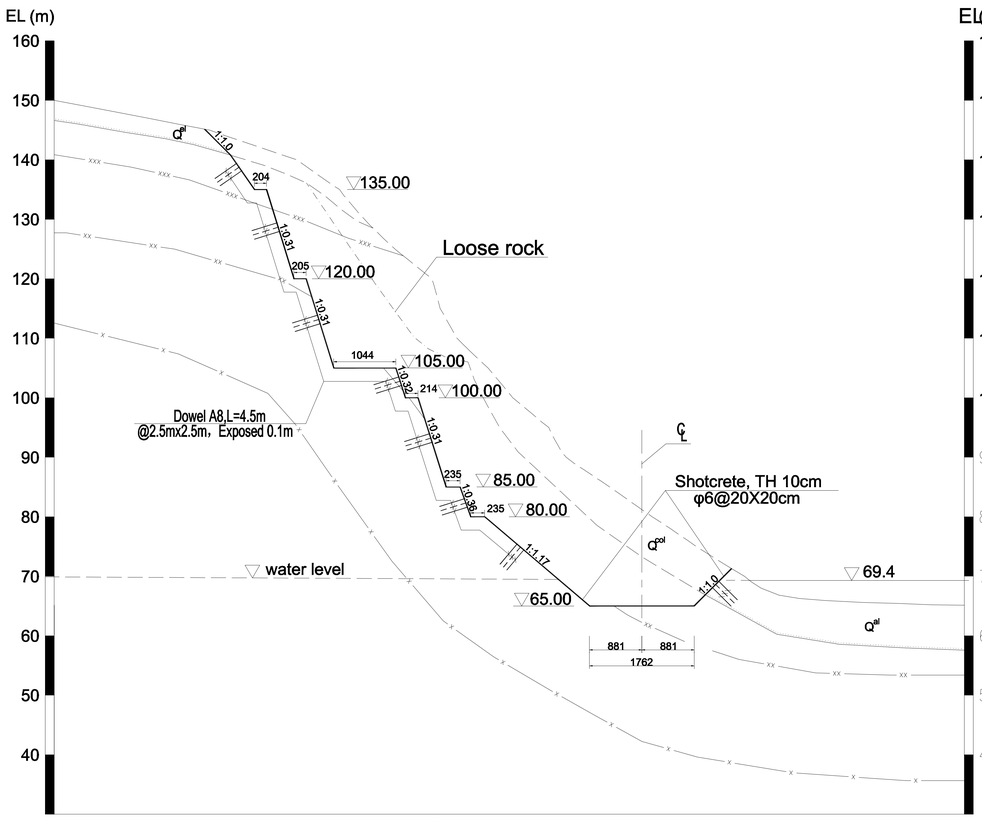
LONGITUDINAL EXCAVATION FOR DIVERSION TUNNEL OUTLET

Detail Design

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Document no. RUF-SHC360-ULX-&CTA010-001001	Rev. B	PAGE NO. 2/4

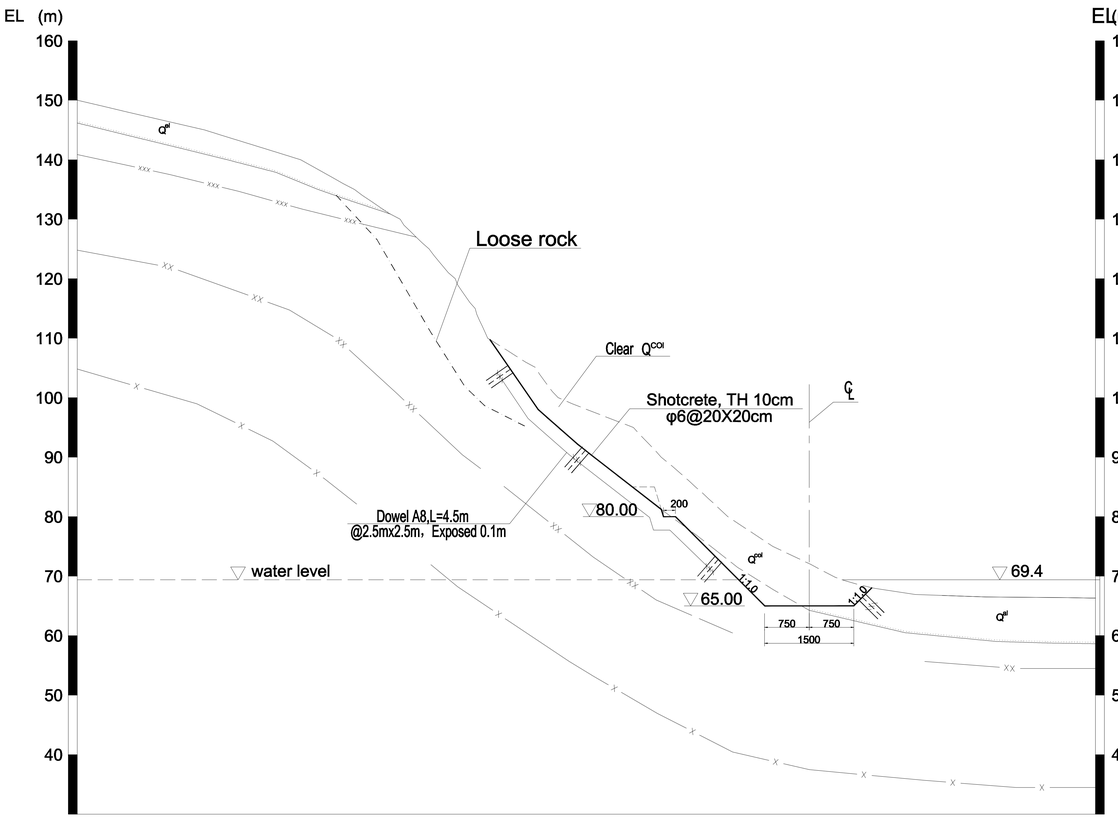
A-A Profile

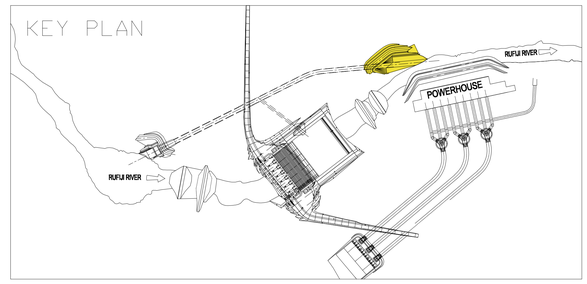
SCALE A



B-B Profile

SCALE A





LEGEND

- FAULT DEBRIS
- Q^{COI} RUBBLES ANA ANGULAR CODDLES (COLLAPSE)
- Q^{al} SAND GRAVEL (ALLUVIAL)
- SS
- MS
- Q^{el} SILTY CLAY (RESIDUAL)
- THE BOUNDARY BETWEEN OVERBURDEN AND BEDROCK
- STRONG-WEATHERING BOUNDARY
- WEAK—WEATHERING BOUNDARY
- WATER LEVEL
- STRONG— UNLOADING BOUNDARY
- MEDIUM-WEATHERING BOUNDARY
- FAULT BRECCIA

Notes:

1.This set of drawings is the excavation drawing of diversion tunnel exit of Rufiji Hydropower Station Project, 4 in total,this is the 3st;

2.The dimensions in this drawing are all in cm except for elevation measured in m and steel bar diameter, drain hole diameter in mm;

3. Drain hole diameter 50, plum blossom layout, row spacing 3.0 mx3.0 m, length 3.0 m, elevation 10 degrees should be set in the Shotcrete part;

4. Before excavating the OUTLET of diversion tunnel, it is necessary to clean up the upper loose rock mass.

0 5 10 25m

GRAPHIC SCALE A 1:500

Originator

The Arab Contractors Osman Ahmad Osman & Co.

ELSEWEDY ELECTRIC

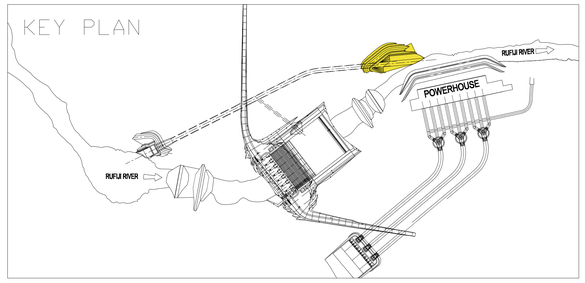
Title

Detail Design

EXCAVATION OF DIVERSION TUNNEL OUTLET

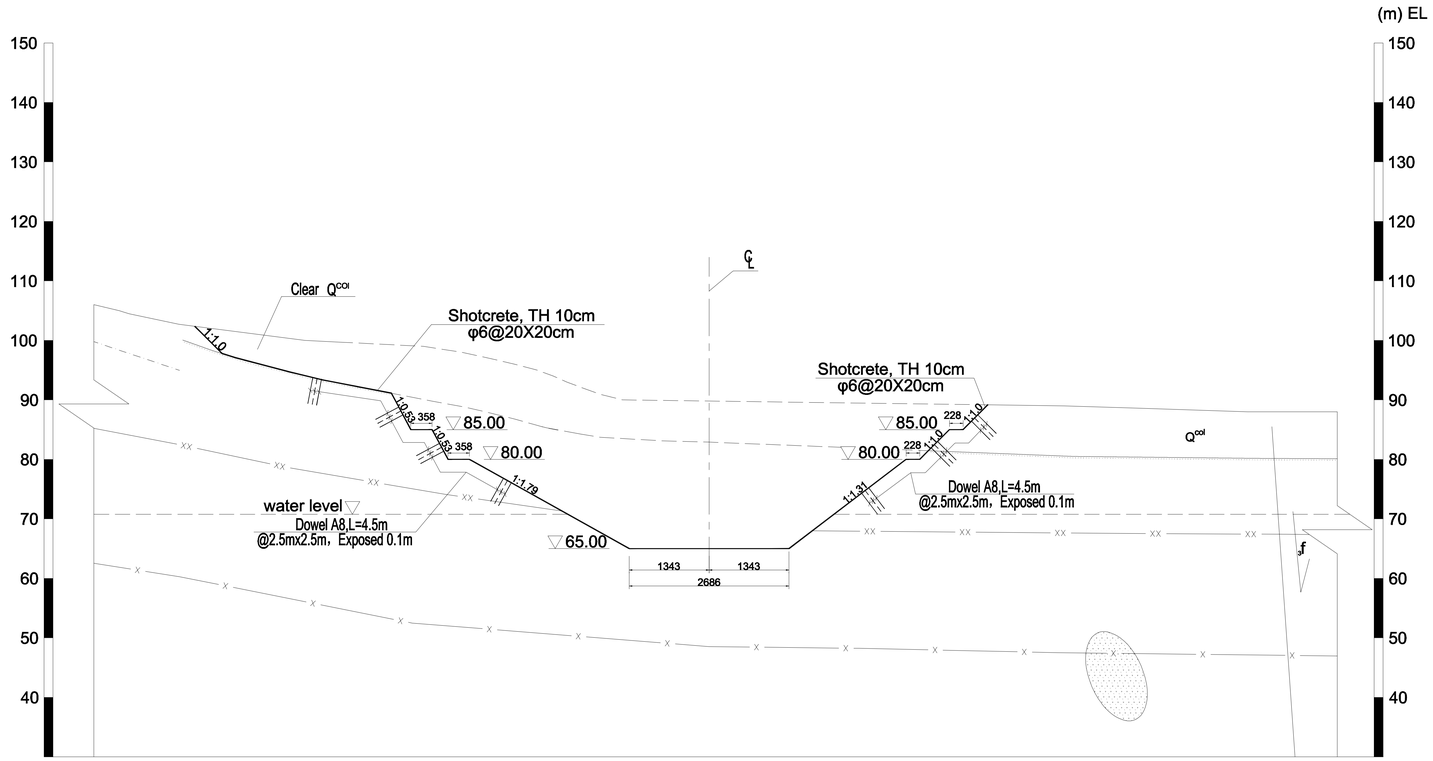
SECTION PROFILE EXCAVATION FOR DIVERSION TUNNEL OUTLET

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Document no. RUF-SHC360-ULX-&CTA010-001001	Rev. B	PAGE NO. 3/4



C-C Profile

SCALE A



LEGEND

- FAULT DEBRIS
- Q^{col} RUBBLES ANA ANGULAR CODDLES (COLLAPSE)
- Q^{al} SAND GRAVEL (ALLUVIAL)
- SS
- MS
- Q^{el} SILTY CLAY (RESIDUAL)
- FAULT BRECCIA
- THE BOUNDARY BETWEEN OVERBURDEN AND BEDROCK
- STRONG-WEATHERING BOUNDARY
- WEAK—WEATHERING BOUNDARY
- WATER LEVEL
- STRONG— UNLOADING BOUNDARY
- MEDIUM-WEATHERING BOUNDARY

Notes:

1. This set of drawings is the excavation drawing of diversion tunnel exit of Rufiji Hydropower Station Project, 4 in total,this is the 4st;
2. The dimensions in this drawing are all in cm except for elevation measured in m and steel bar diameter, drain hole diameter in mm;
3. Drain hole diameter 50, plum blossom layout, row spacing 3.0 mx3.0 m, length 3.0 m, elevation 10 degrees should be set in the Shotcrete part;
4. Before excavating the OUTLET of diversion tunnel, it is necessary to clean up the upper loose rock mass.

0 5 10 25m

GRAPHIC SCALE A 1:500

Originator

The Arab Contractors OSMAN AHMAD OSMAN & CO.

ELSEWEDY ELECTRIC

Title

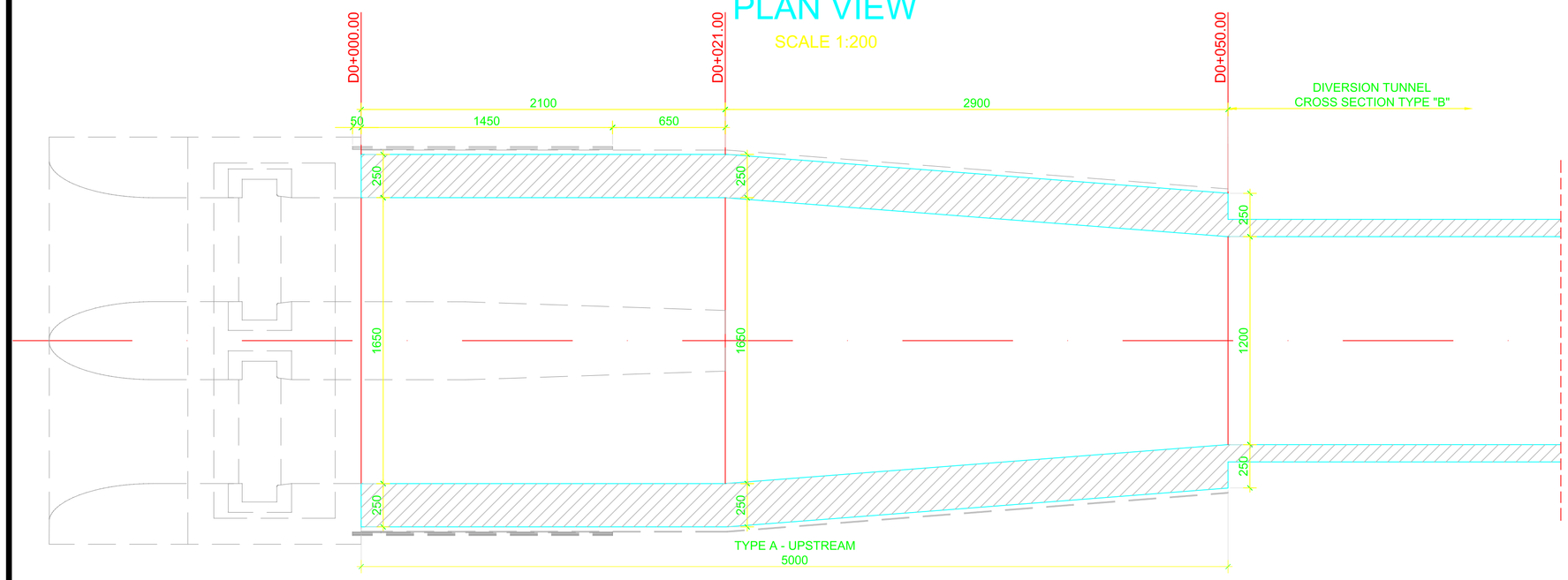
Detail Design

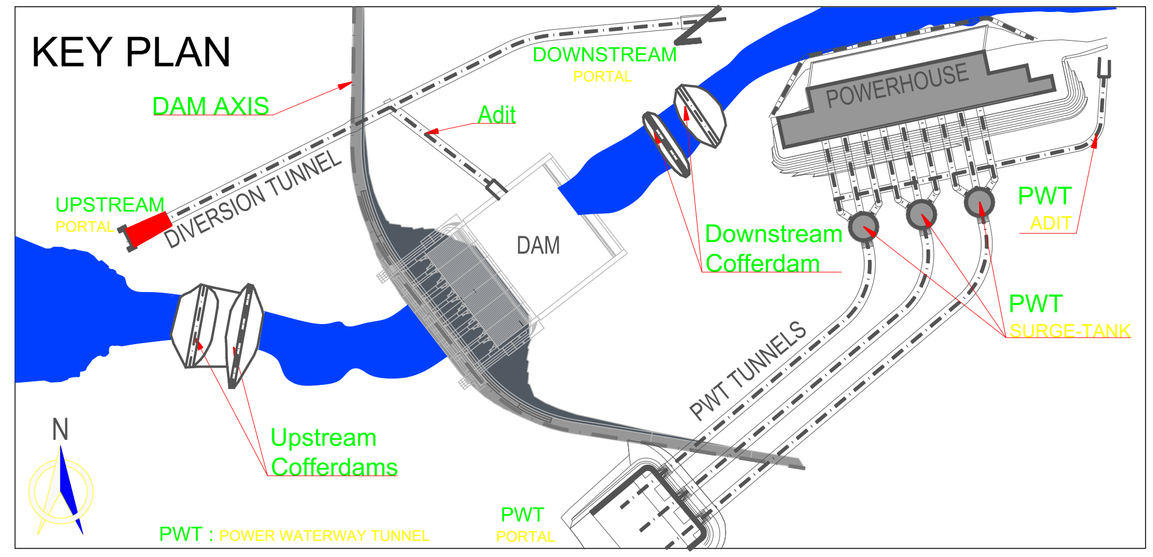
EXCAVATION OF DIVERSION TUNNEL OUTLET

SECTION PROFILE EXCAVATION FOR DIVERSION TUNNEL OUTLET

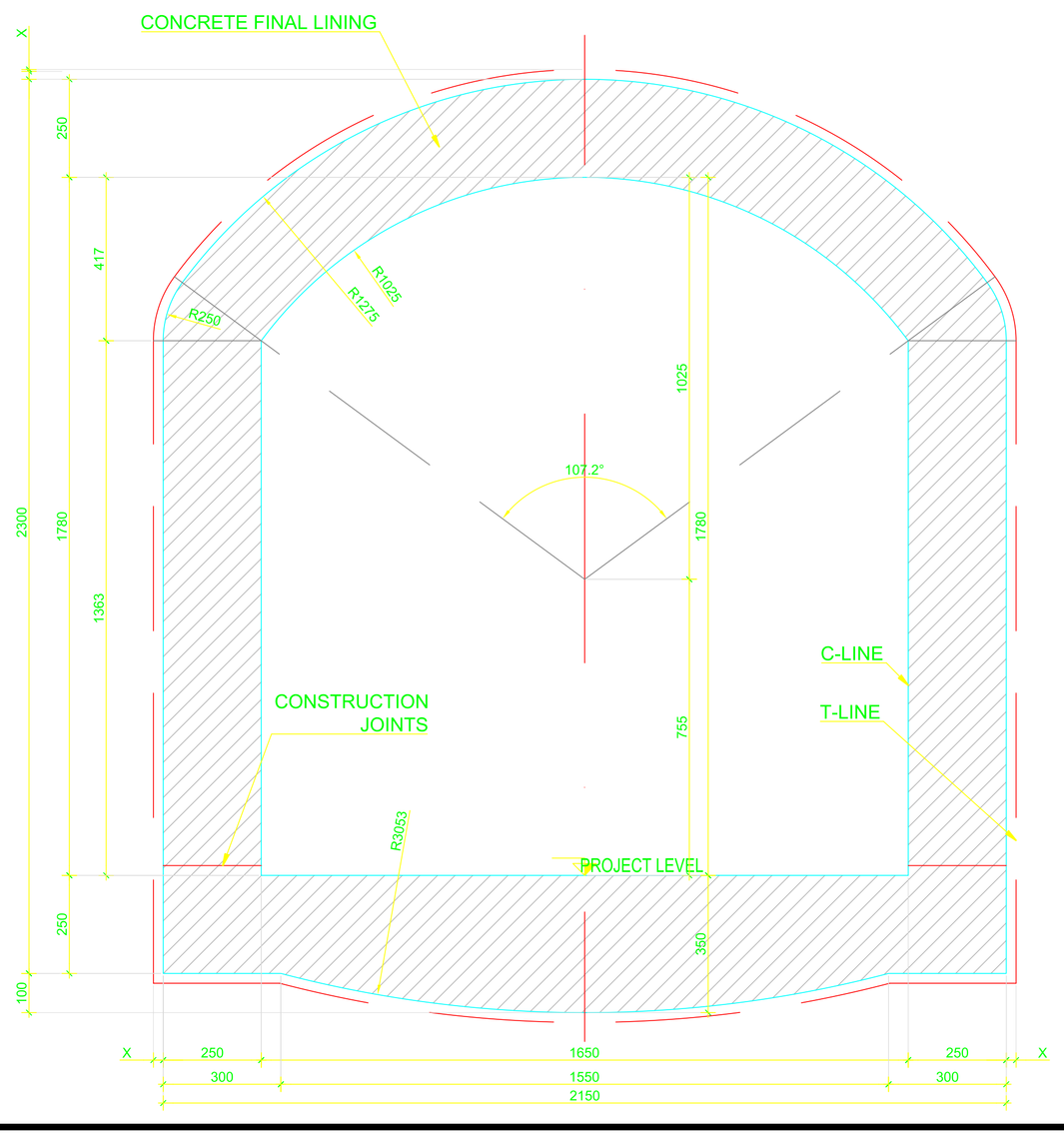
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PLAN VIEW
SCALE 1:200

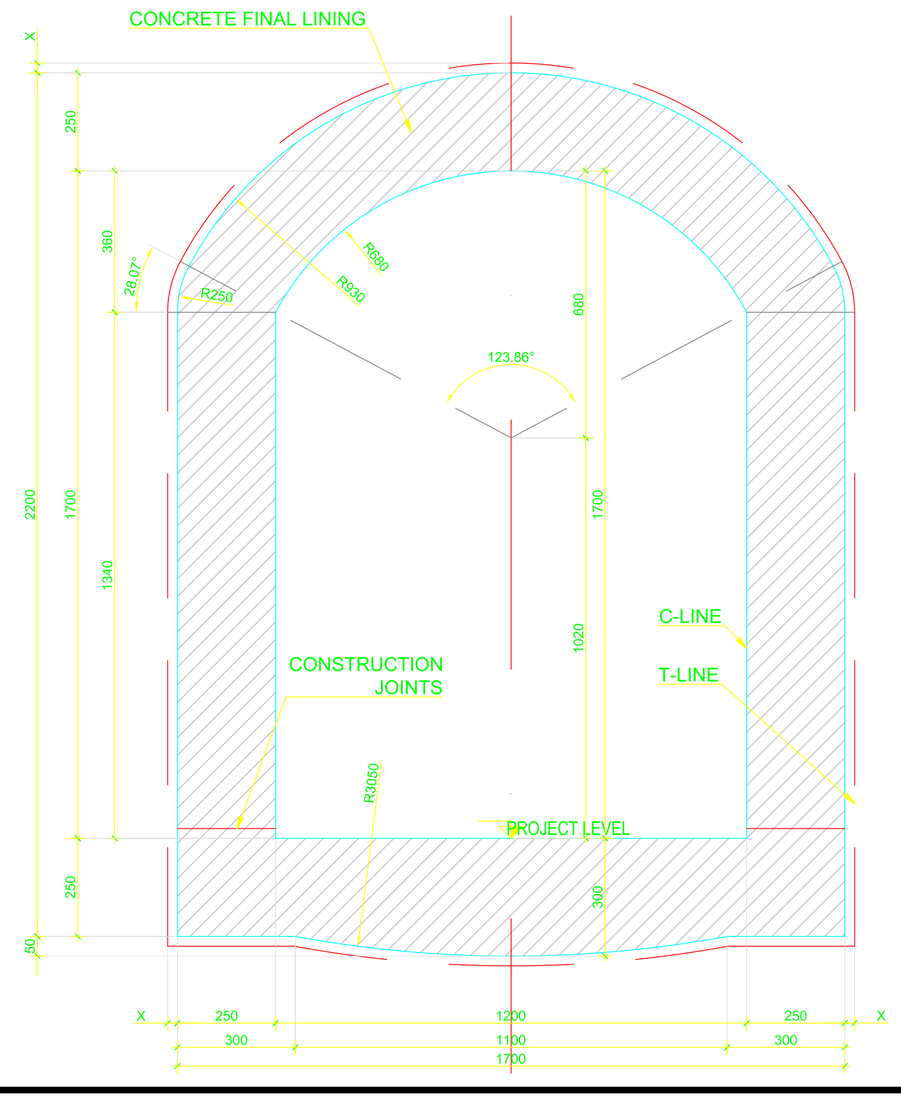




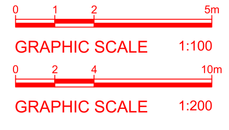
FINAL LINING (D0+021)
SCALE 1:100



FINAL LINING (D0+050)
SCALE 1:100



GENERAL NOTES:
1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE FINAL LINING SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, ANCHOR BARS AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED



Originator

TheArabContractors
OSMAN AHMAD OSMAN & CO
المقاولون العرب
عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

DIVERSION TUNNEL
SECTION

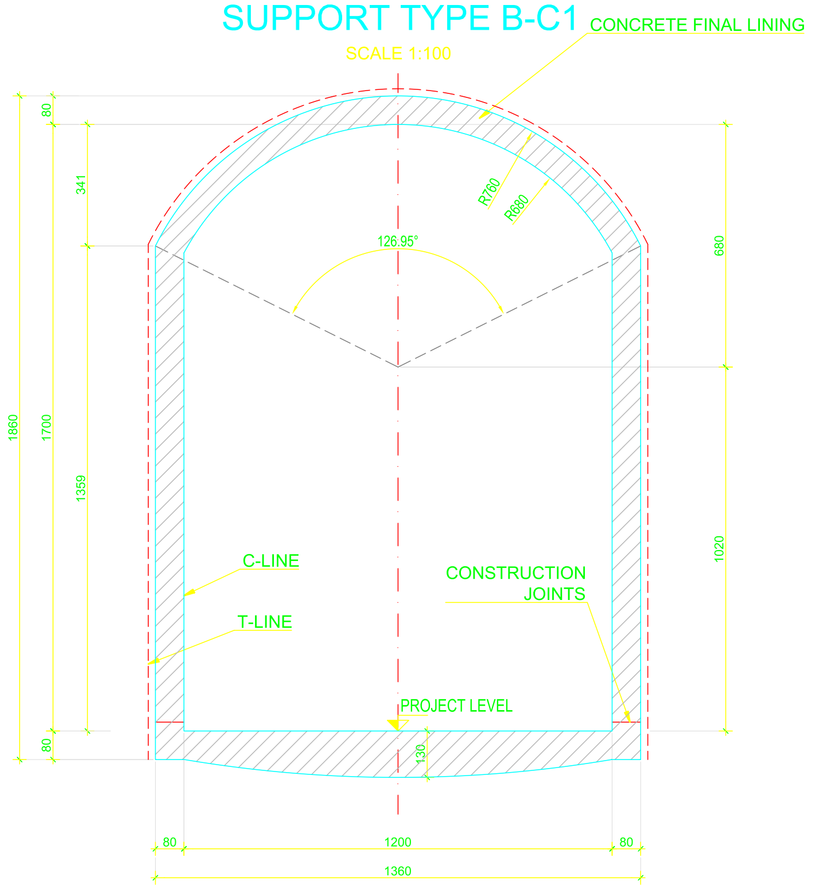
Detial Design

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Document no.	Rev.	PAGE NO.
RUF-SHC300-ULX-&CTA010-001002	Rev. B	1/4

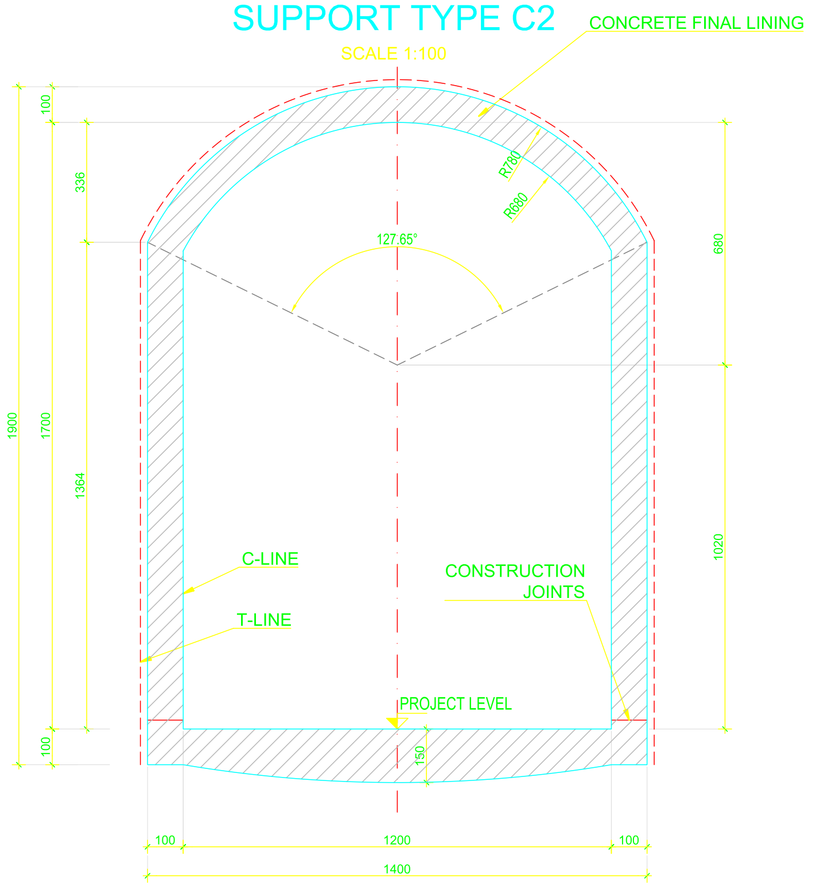
FINAL LINING FOR SUPPORT TYPE B-C1

SCALE 1:100



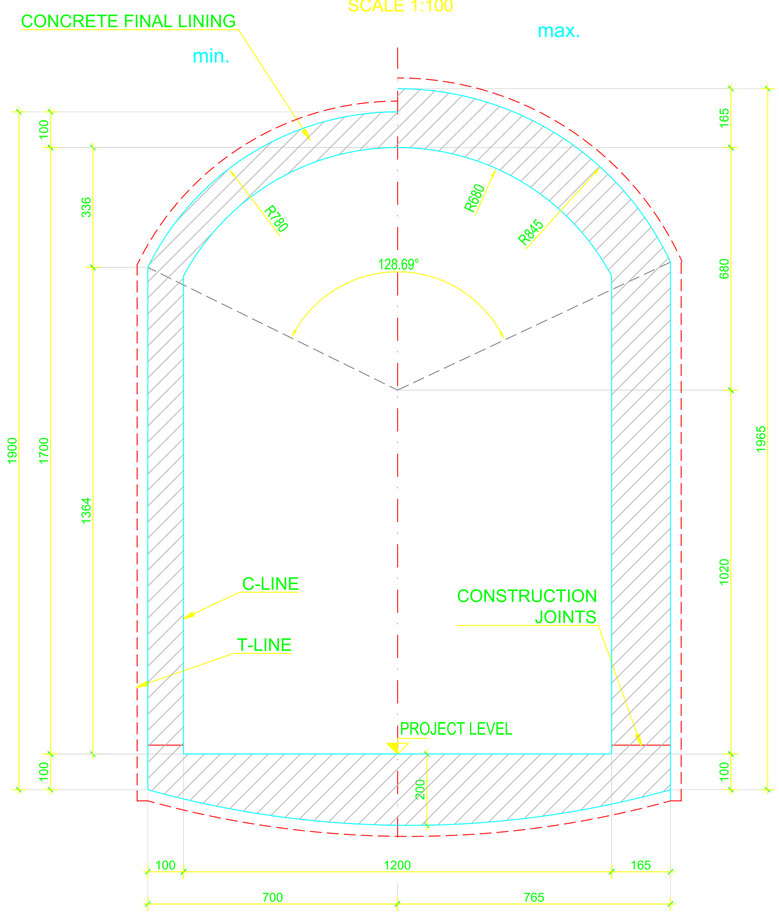
FINAL LINING FOR SUPPORT TYPE C2

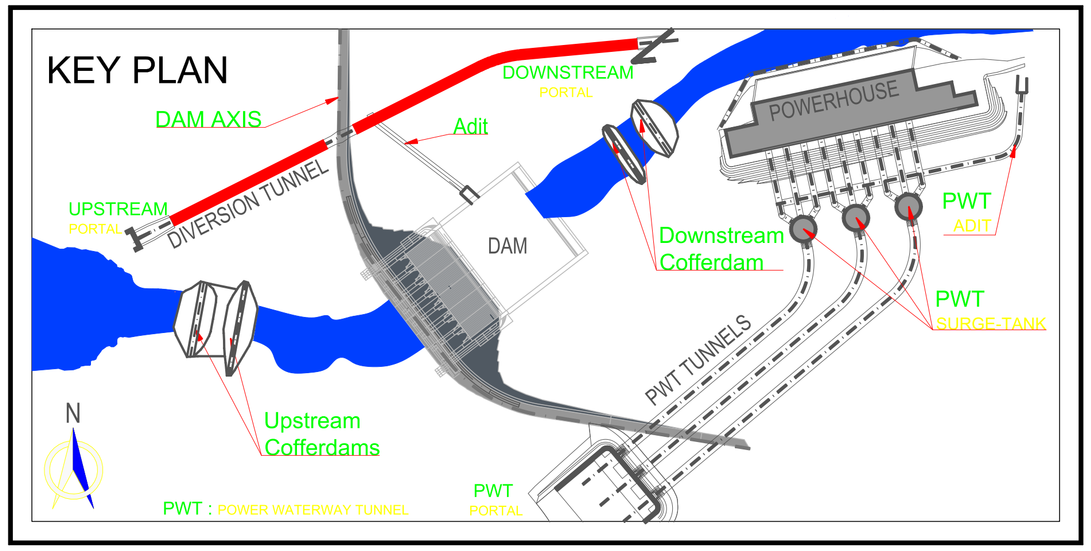
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FINAL LINING FOR SUPPORT TYPE F

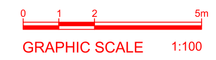
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GENERAL NOTES:

1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE FINAL LINING SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, ANCHOR BARS AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED
4. FOR SPECIFIC NOTES REFER TO DRAWING RUFIJI-SHC-ULU-CLH060-00-6/8



Originator

TheArabContractors
OSMAN AHMAD OSMAN & CO.
المقاولون العرب
عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

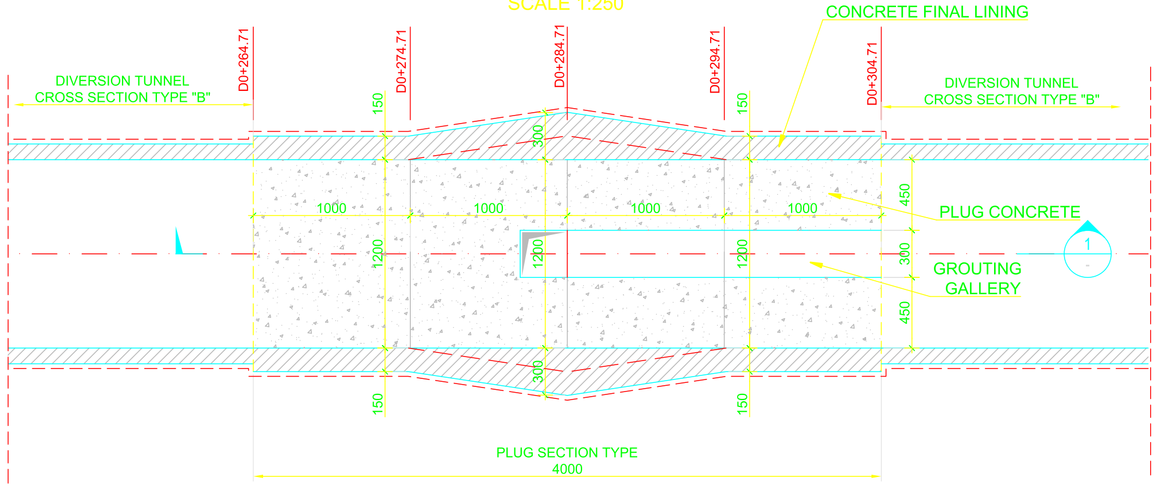
DIVERSION TUNNEL
SECTION

Detial Design

Type: BLACK	Scale: As Shown	Size: A3
Document no. RUF-SHC300-ULX-&CTA010-001002	Rev. B	PAGE NO. 2/4

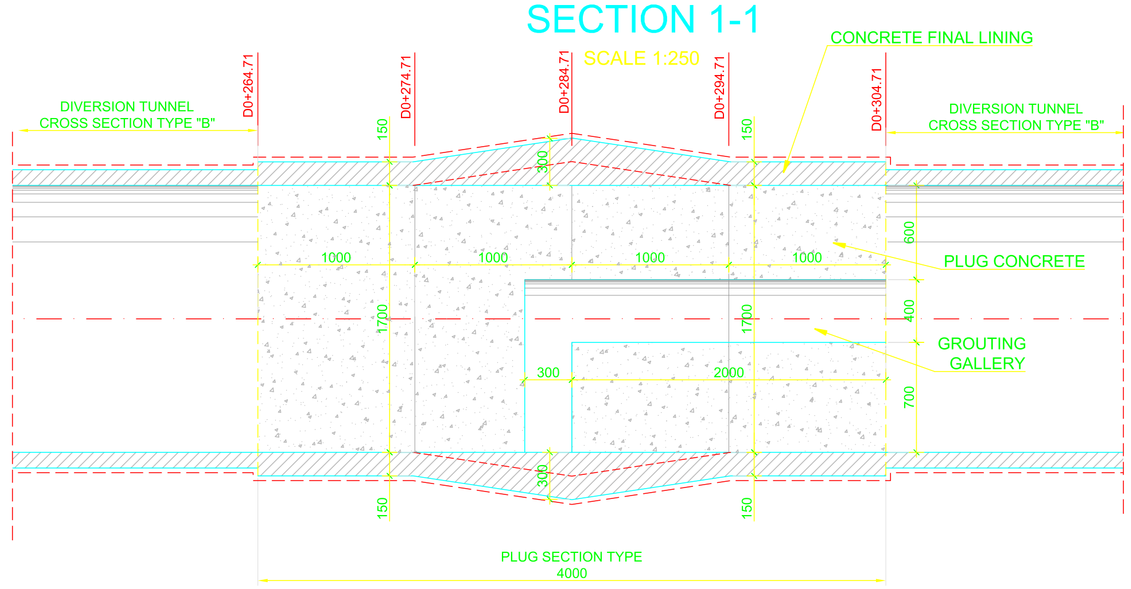
PLAN VIEW

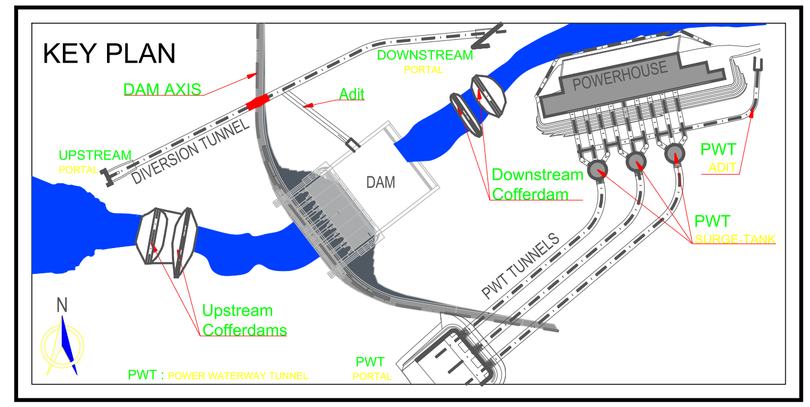
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SECTION 1-1

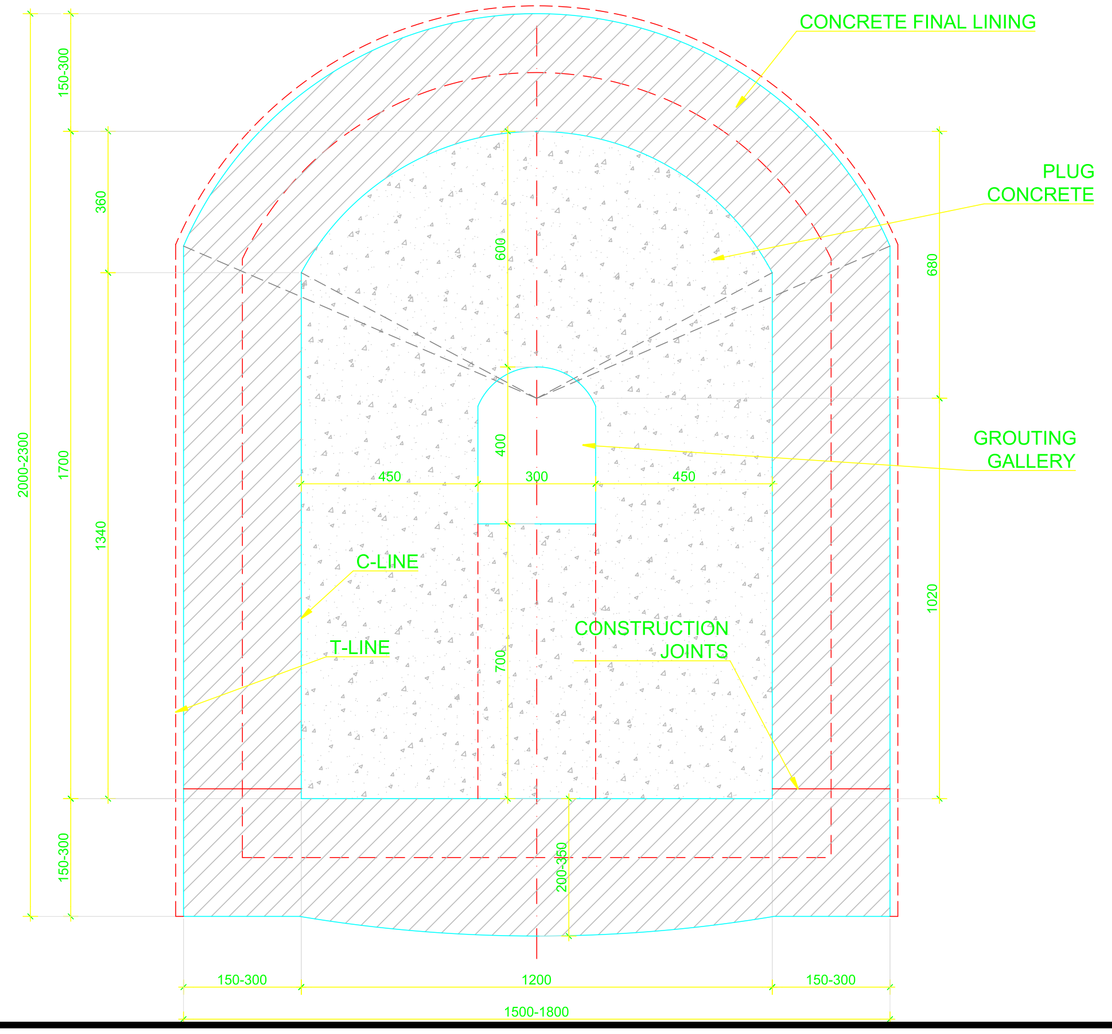
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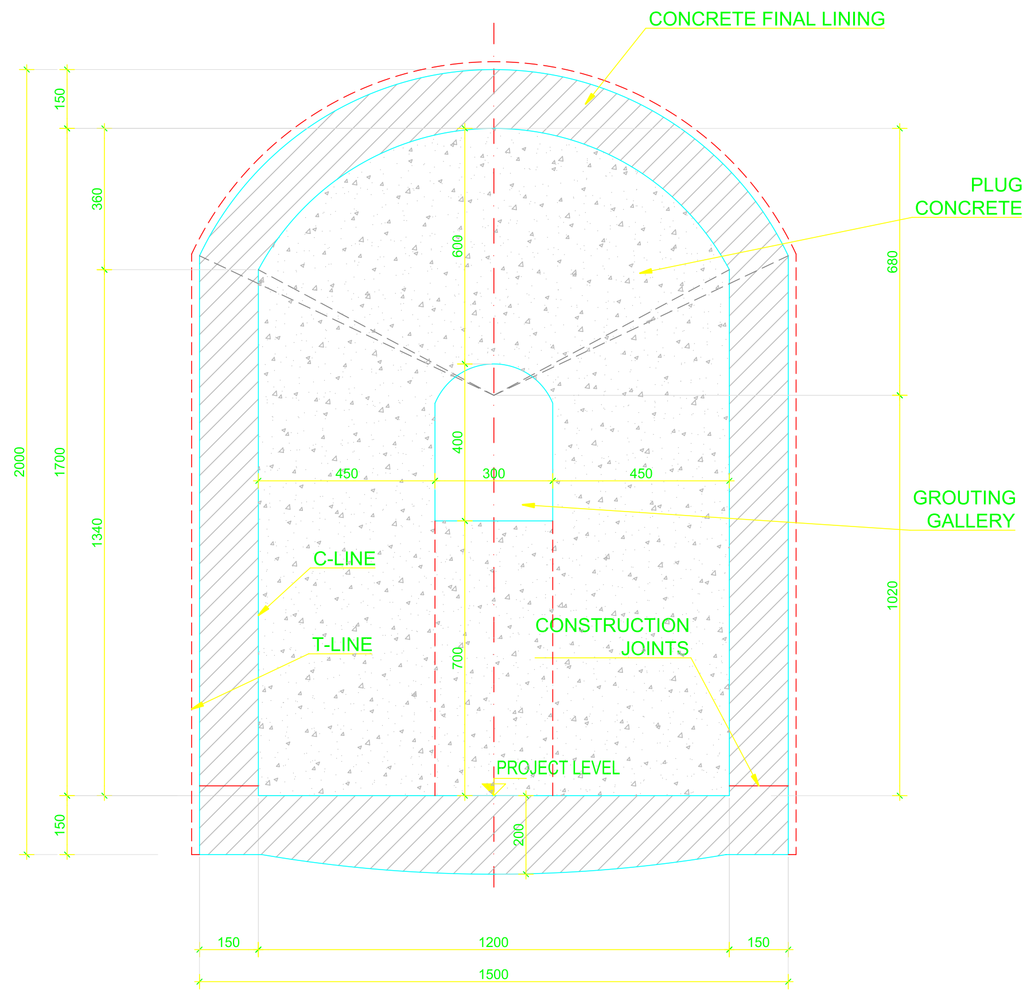
FINAL LINING FOR SUPPORT TYPE C1-C2 (max) (CH 0+284.71)

SCALE 1:100



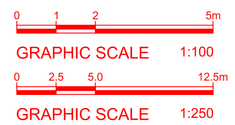
FINAL LINING FOR SUPPORT TYPE C1-C2 (min) (CH 0+264.71÷0+274.71) (CH 0+294.71÷0+304.71)

SCALE 1:100



GENERAL NOTES:

1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE FINAL LINING SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, ANCHOR BARS AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED



Originator

TheArabContractors
OSMAN AHMAD OSMAN & CO.
المقاولون العرب
عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

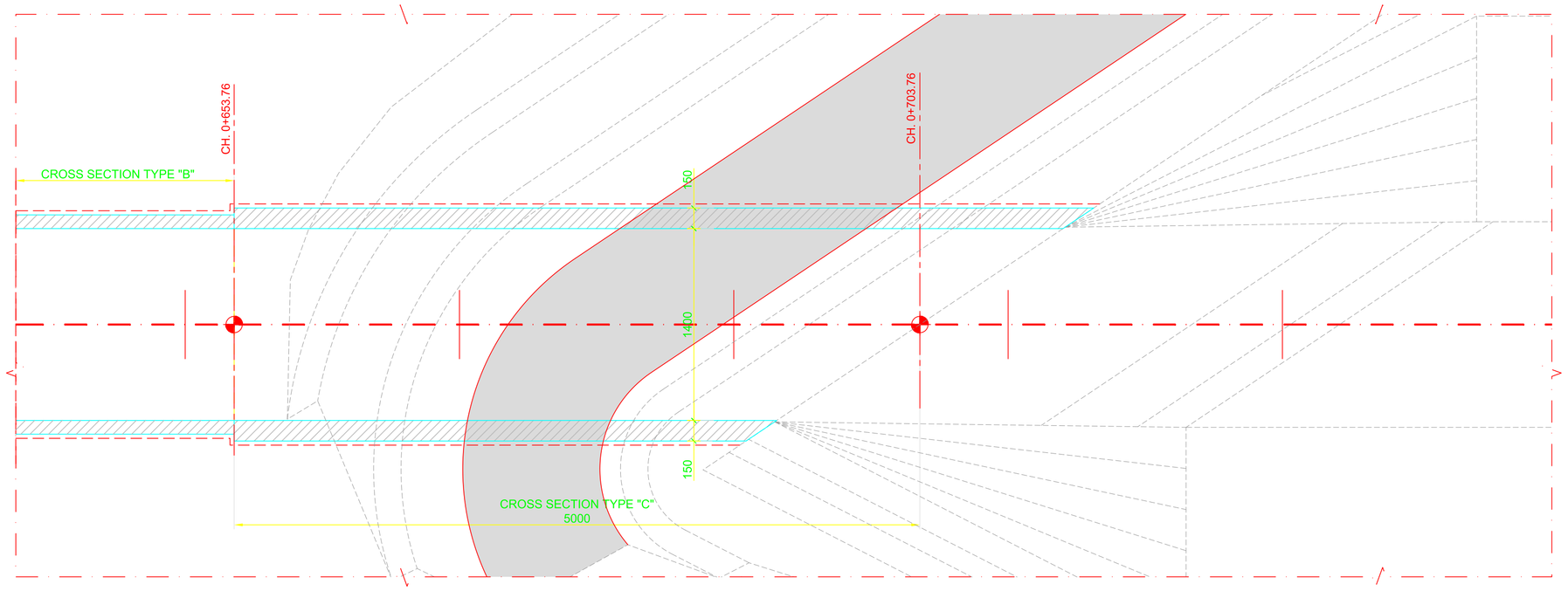
DIVERSION TUNNEL
SECTION

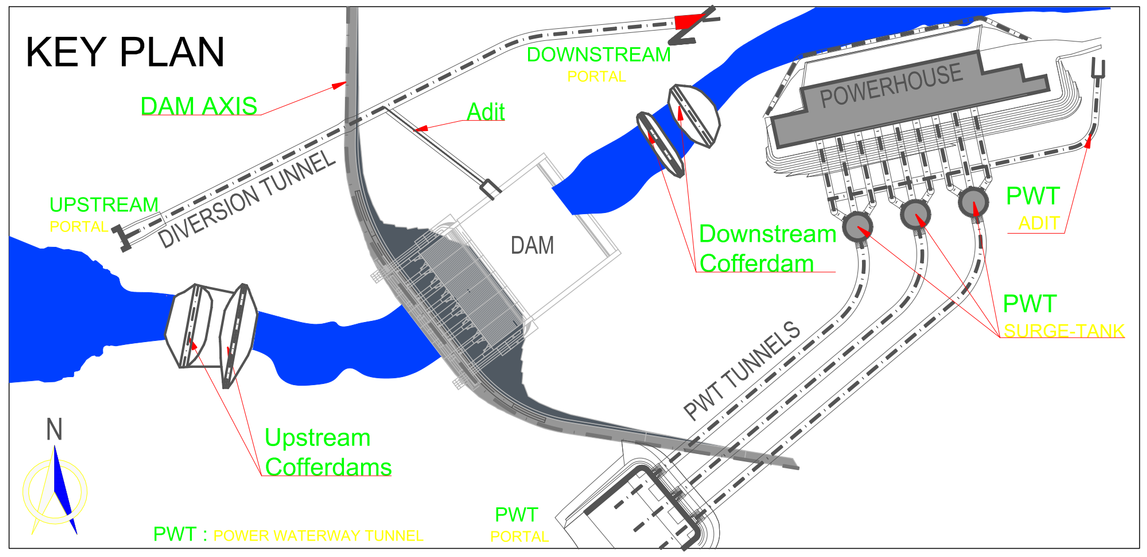
Detial Design

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Document no. RUF-SHC300-ULX-&CTA010-001002	Rev. B	PAGE NO. 3/4

PLAN VIEW

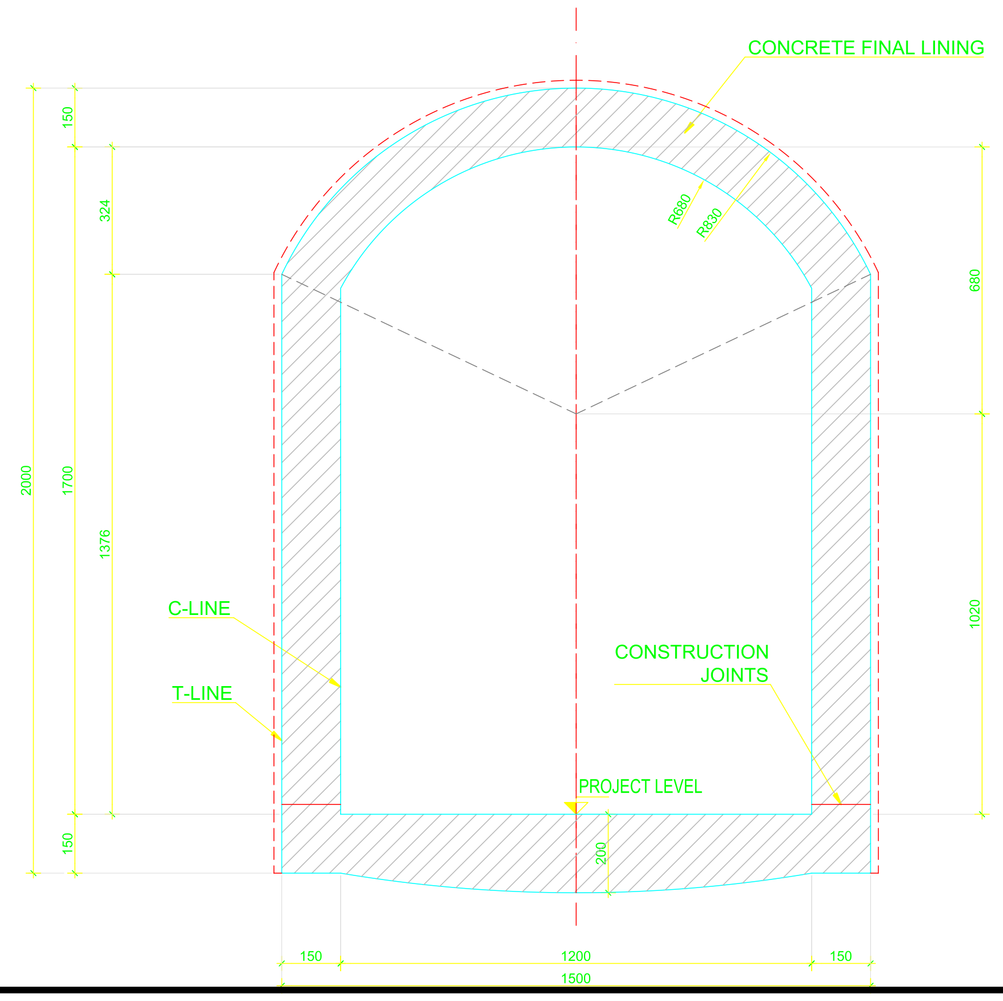
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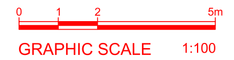
FINAL LINING FOR SUPPORT TYPE C1-C2

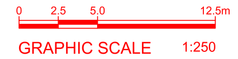
SCALE 1:100



GENERAL NOTES:

1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE FINAL LINING SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, ANCHOR BARS AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED





Originator

TheArabContractors OSMAN AHMAD OSMAN & CO

ELSEWEDY ELECTRIC

Title

DIVERSION TUNNEL
SECTION

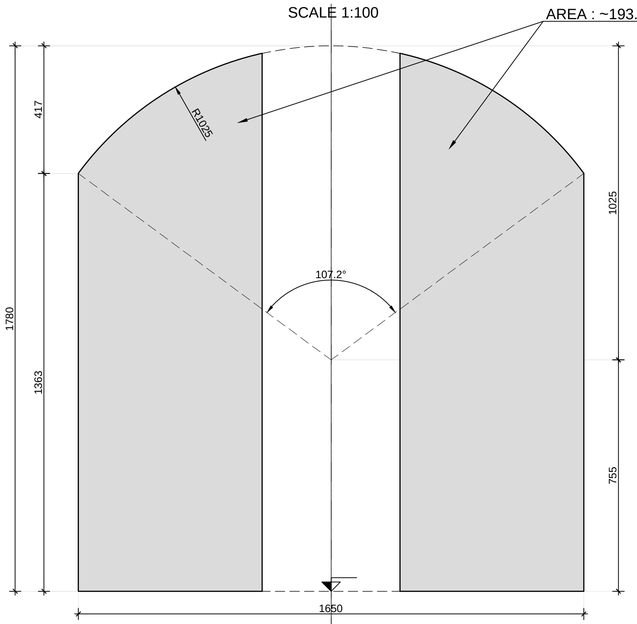
Detial Design

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Document no.	Rev.	PAGE NO.
RUF-SHC300-ULX-&CTA010-001002	Rev. B	4/4

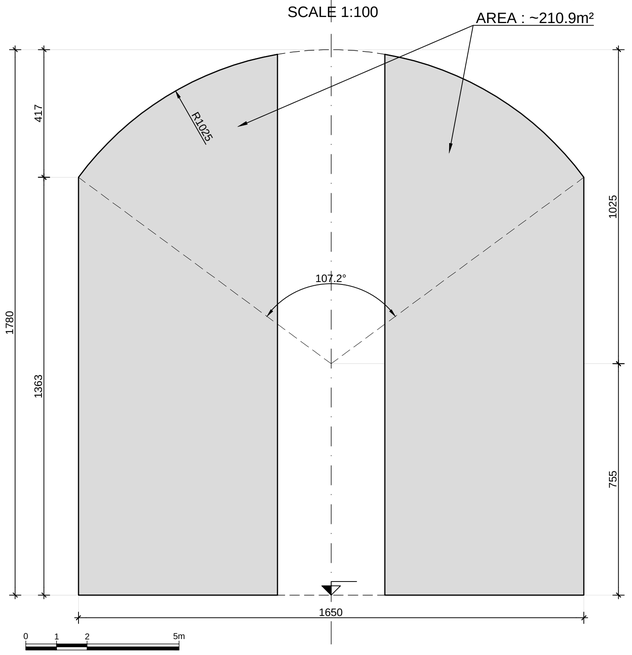
OPERATIONAL WORKS
HYDRAULIC CLEARANCE (D0+000)

SCALE 1:100



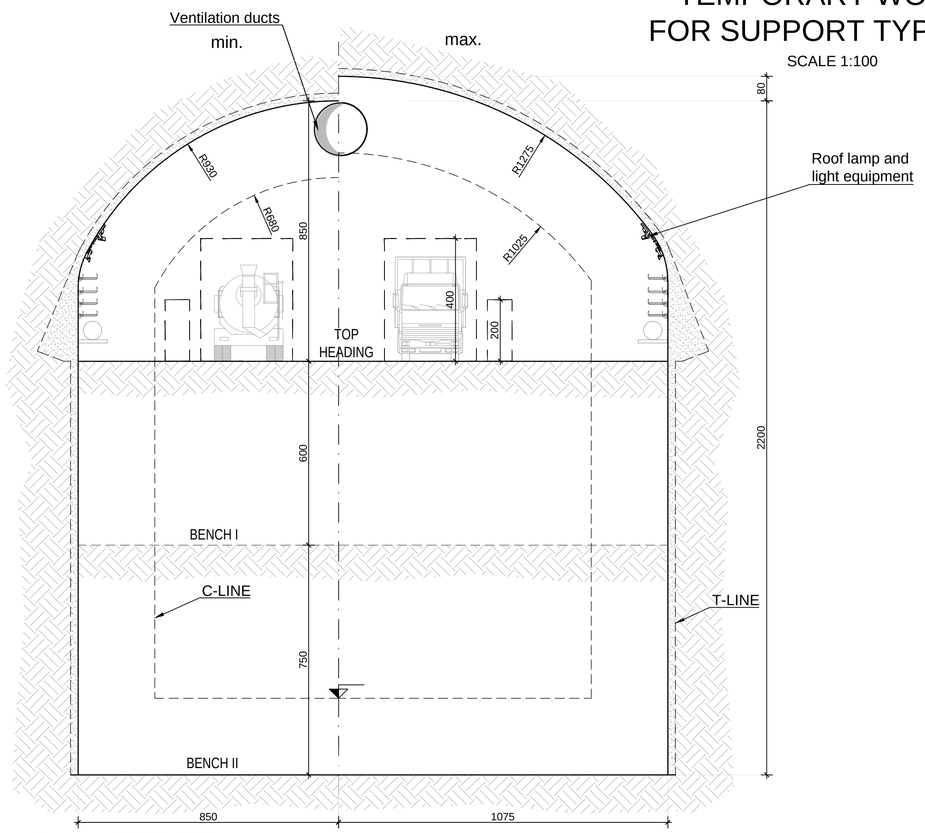
OPERATIONAL WORKS
HYDRAULIC CLEARANCE (D0+021)

SCALE 1:100

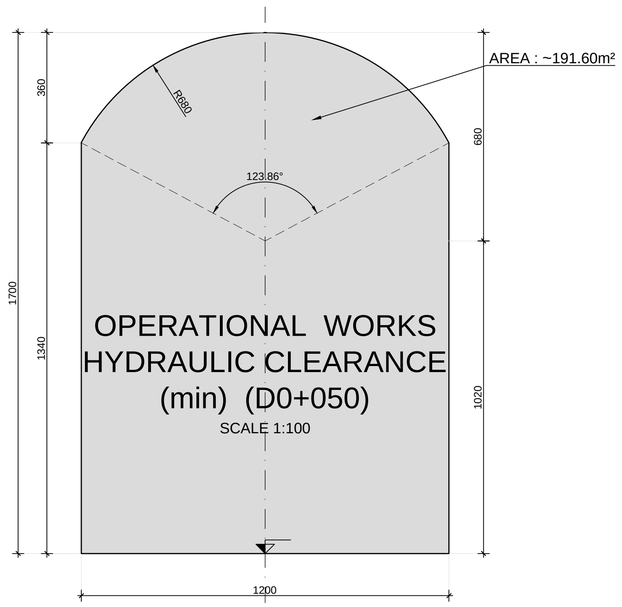


TEMPORARY WORKS
FOR SUPPORT TYPE C2-F

SCALE 1:100

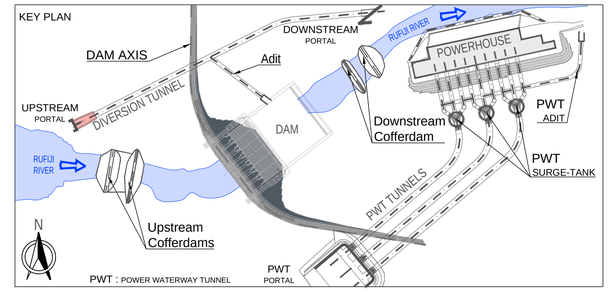


L = FINAL LINING THICKNESS;
X = PRIMARY SUPPORT THICKNESS



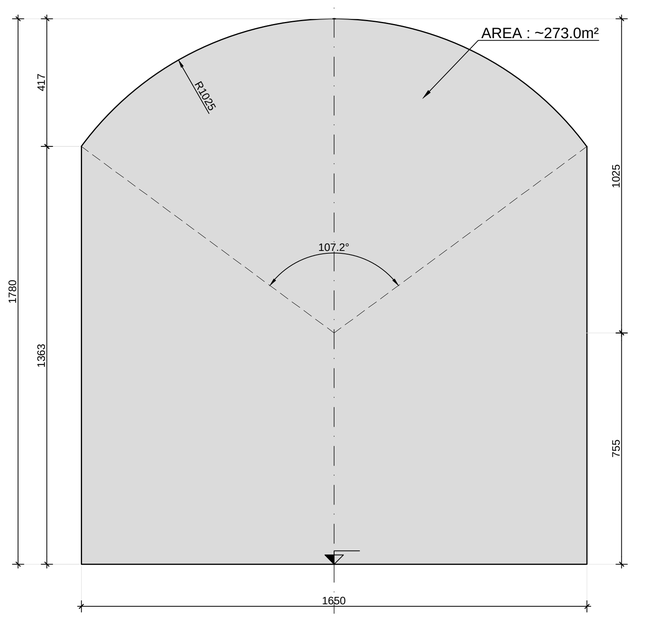
OPERATIONAL WORKS
HYDRAULIC CLEARANCE (min) (D0+050)

SCALE 1:100



OPERATIONAL WORKS
HYDRAULIC CLEARANCE (max) (D0+021)

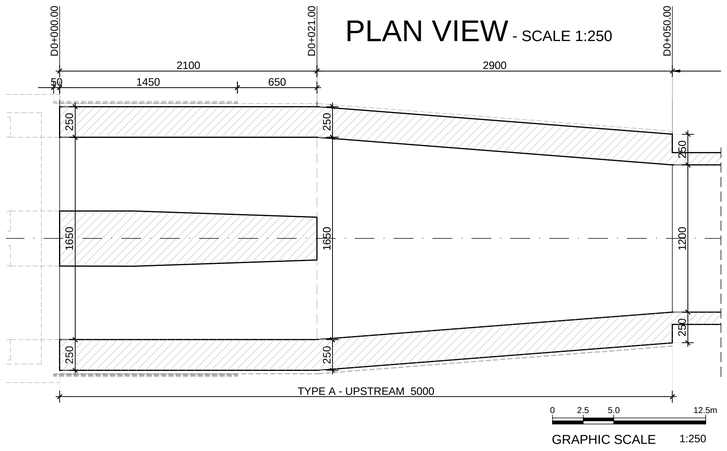
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GENERAL NOTES:

1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE FINAL LINING SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, ROCK DOWEL AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED.
4. THE ARRANGEMENT OF TOP HEADING MULTI DRIFT AND BENCHING EXCAVATION WILL BE CONFIRMED OR OPTIMIZED BY THE CONTRACTOR ACCORDING TO THEIR AVAILABLE EQUIPMENT AND PREFERRED SOLUTIONS

PLAN VIEW - SCALE 1:250



Originator

The Arab Contractors
OSMAN AHMAD OSMAN & CO.
العقاولون العرب
عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

Detail Design

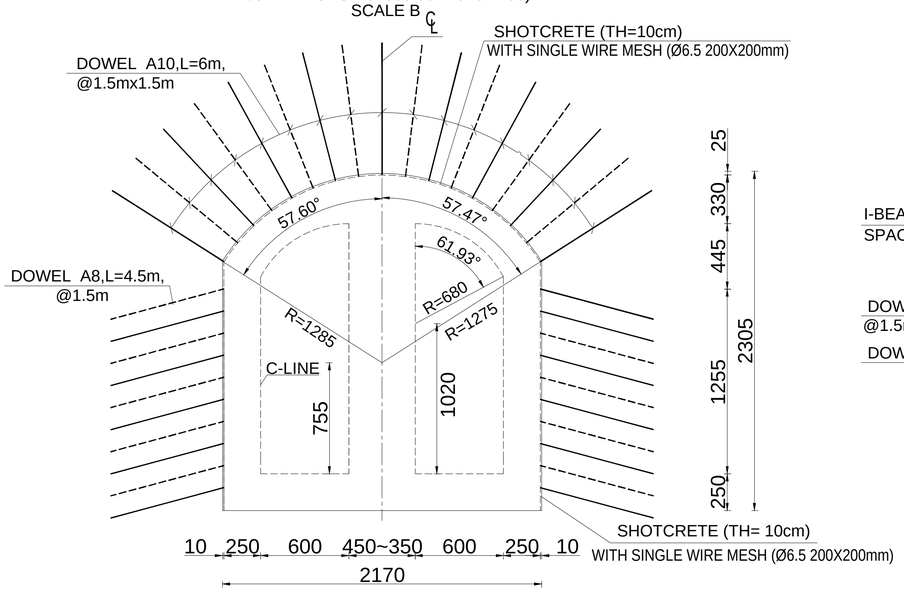
DIVERSION TUNNEL
Typical Cross Section for Transition Zone (Type A - Upstream)
Operational & temporary works

Type: BLACK	Scale: As Shown	Size: A3
Document no. RUF-SHC330-ULX-&CTA010-001002	Rev. 00	PAGE NO. 01

TYPE C1 EXCAVATION SUPPORT DRAWING

（CHAINAGES D0+000.00~D0+021.00)

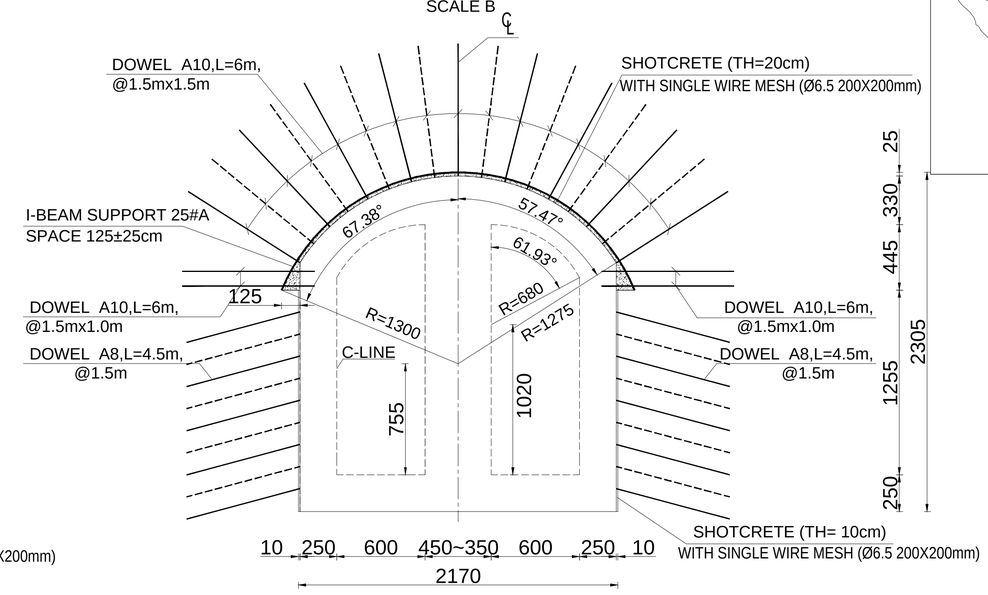
SCALE B



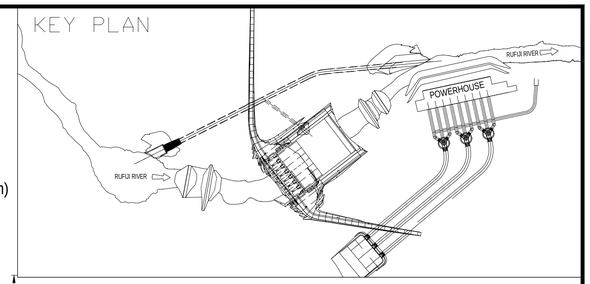
TYPE C2 EXCAVATION SUPPORT DRAWING

（CHAINAGES D0+000.00~D0+021.00)

SCALE B



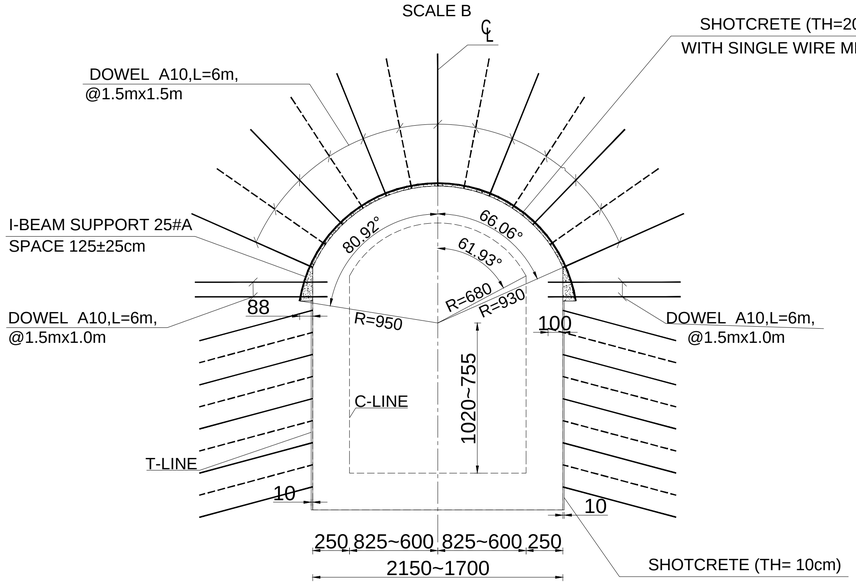
KEY PLAN



TYPE C2 EXCAVATION SUPPORT DRAWING

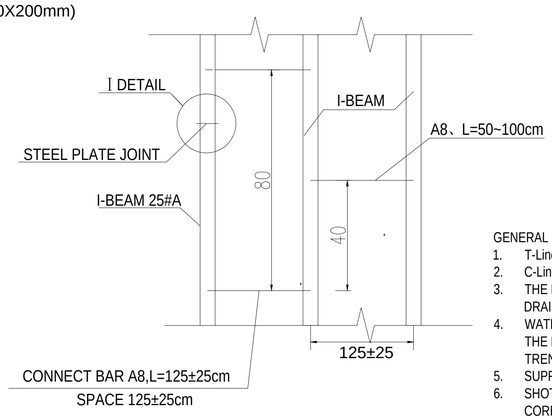
（CHAINAGES D0+021.00~D0+050.00)

SCALE B



I-BEAM SUPPORT LAYOUT

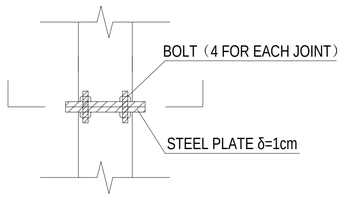
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SCALE A 0 2 4 10m

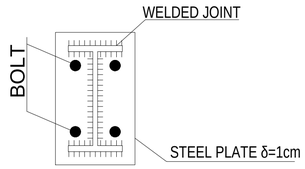
I-I DETAIL

NOT TO SCALE



a-a SECTION

NOT TO SCALE



GENERAL NOTES:

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4. WATER INFLOW EVALUATION DURING CONSTRUCTION WILL ALLOW TO CONFIRM THE PRESENCE OF DRAINAGE SYSTEM AND/OR TO OPTIMIZE THE NUMBER, LENGTH OF DRAINS AND OVERLAPP. WATER FROM ROCK MASS COLLECTED BY DRAINS MUST BE CHANNELIZED IN DRAINAGE TRENCHES.
5. SUPPORT MEASURES ARE DESIGNED ACCORDING TO AVAILABLE GEOLOGICAL DATA, TO BE VERIFIED ON SITE DURING CONSTRUCTION.
6. SHOTCRETE THICKNESS MUST BE INCREASED LOCALLY TO ENSURE MIN 30mm LATTICE GIRDER COVER FOR PROTECTION AGAINST CORROSION.
7. C1 TYPICAL APPLICATION RANGE OF RMR :60 >RMR>40. C2 TYPICAL APPLICATION RANGE OF RMR :40 >RMR>20.
8. THE ARRANGEMENT OF TOP HEADING MULTI DRIFT AND BENCHING EXCAVATION WILL BE CONFIRMED OR OPTIMIZED BY THE CONTRACTOR ACCORDING TO THEIR AVAILABLE EQUIPMENT AND PREFERRED SOLUTIONS. ACCORDING TO THE DESIGN SOLUTION, ADDITIONAL SUPPORTS SHALL BE INSTALLED ALONG THE TEMPORARY LATERAL SIDEWALLS (I.E. ADDITIONAL SHOTCRETE LAYER WITH ROCK DOWEL AND STEEL RIB ARCH WHERE REQUIRED) TO ENSURE SAFE CONDITIONS DURING.
9. THE CHOICE OF THE SUPPORT SECTION TYPE OF DESIGN TO BE APPLIED IS BASED ON GEOMECHANICAL CONDITIONS AT TUNNEL FACE DEFINED BY FACE MAPPING. EACH SECTION TYPE HAS A SPECIFIC FIELD OF APPLICATION BASED ON DEFINED GEOMECHANICAL CONDITIONS. THE SUPPORT VARIABILITY INCLUDED IN EACH SUPPORT SECTION TYPE IS MANAGED ON SITE ON THE BASIS OF VISUAL INSPECTION, EXCAVATION BEHAVIOUR AND MONITORING RESULTS BY THE DESIGN REPRESENTATIVE.

Originator

TheArabContractors OSMAN AHMAD OSMAN & CO. المقاولون العرب حسان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

TRANSITION OF DIVERSION TUNNEL

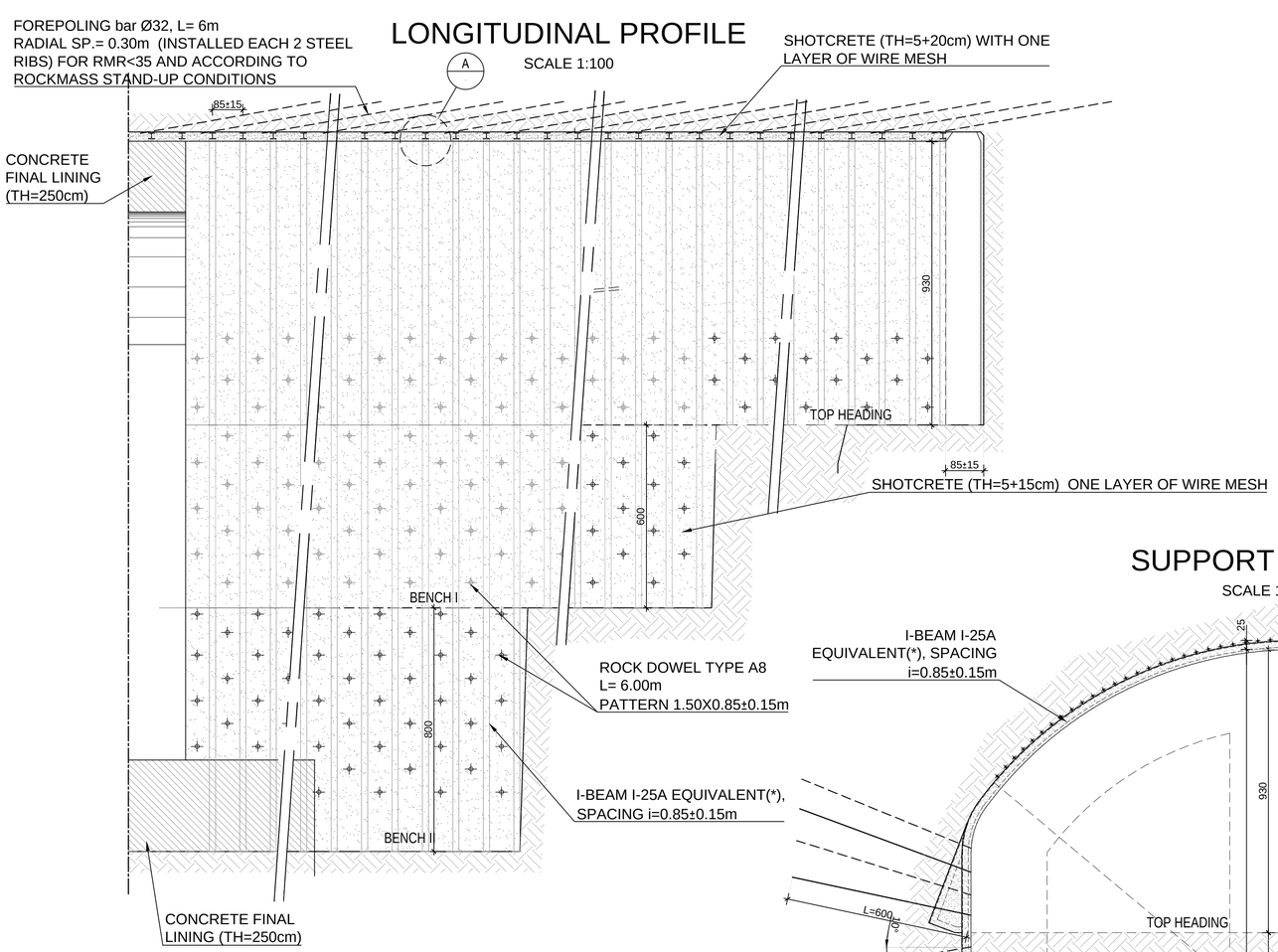
EXCAVATION AND SUPPORT DRAWING

Detail Design

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Document no. RUF-SHC330-ULX-&CTA010-001002	Rev. 00	PAGE NO. 02

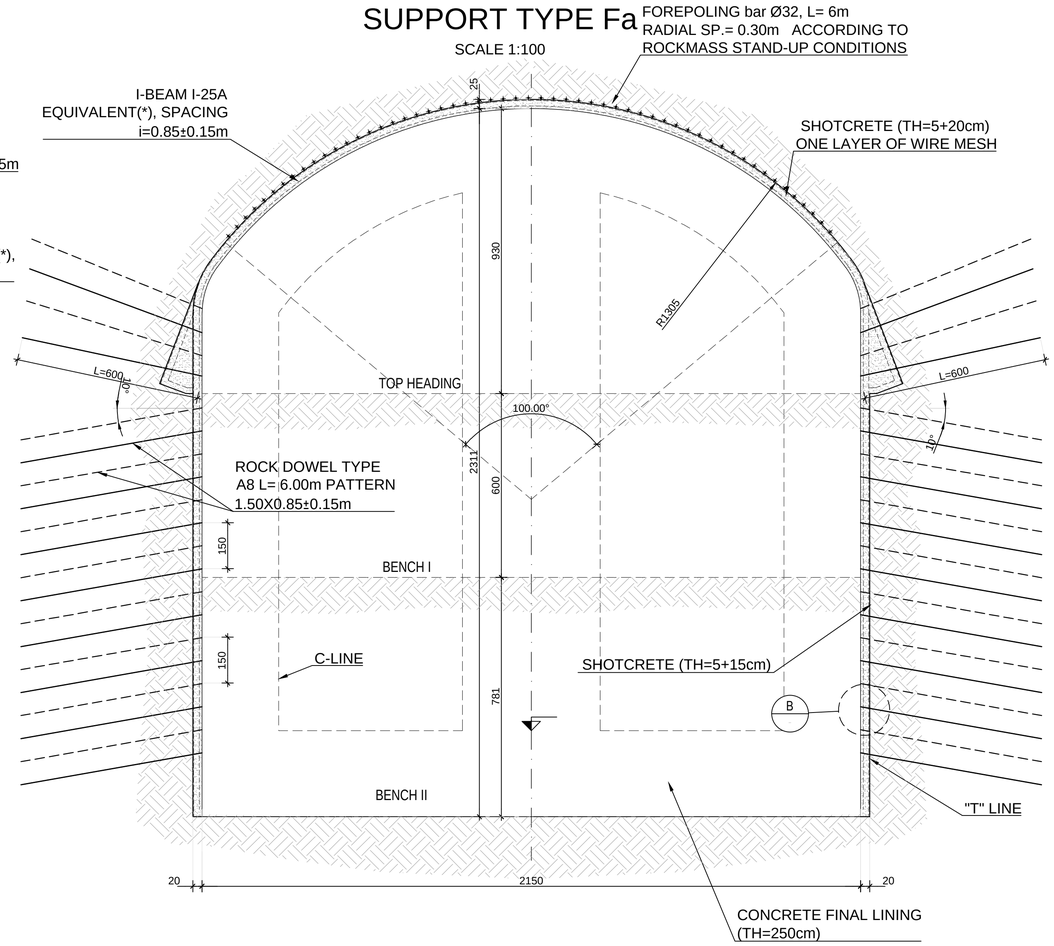
LONGITUDINAL PROFILE

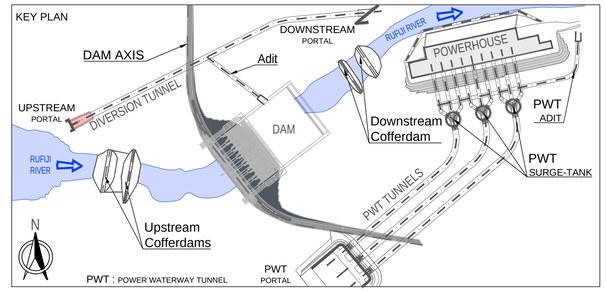
SCALE 1:100



SUPPORT TYPE Fa

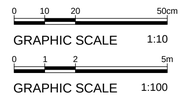
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4. WATER INFLOW EVALUATION DURING CONSTRUCTION WILL ALLOW TO CONFIRM THE PRESENCE OF DRAINAGE SYSTEM AND/OR TO OPTIMIZE THE NUMBER, LENGTH OF DRAINS AND OVERLAPP. WATER FROM ROCK MASS COLLECTED BY DRAINS MUST BE CHANNELIZED IN DRAINAGE TRENCHES.
5. SUPPORT MEASURES ARE DESIGNED ACCORDING TO AVAILABLE GEOLOGICAL DATA, TO BE VERIFIED ON SITE DURING CONSTRUCTION.
6. TO ENSURE SAFETY FIRST MIN 30mm OF SHOTCRETE SHALL BE INSTALLED ON ALL EXPOSED SURFACE IMMEDIATELY AFTER EXCAVATION.
7. TYPICAL APPLICATION RANGE OF RMR : 15<RMR<20 (Fa) AND RMR<15 (Fb).
8. THE ARRANGEMENT OF TOP HEADING MULTI DRIFT AND BENCHING EXCAVATION WILL BE CONFIRMED OR OPTIMIZED BY THE CONTRACTOR ACCORDING TO THEIR AVAILABLE EQUIPMENT AND PREFERRED SOLUTIONS. ACCORDING TO THE DESIGN SOLUTION, ADDITIONAL SUPPORTS SHALL BE INSTALLED ALONG THE TEMPORARY LATERAL SIDEWALLS (I.E. ADDITIONAL SHOTCRETE LAYER WITH ROCK DOWEL AND STEEL RIB ARCH WHERE REQUIRED) TO ENSURE SAFE CONDITIONS DURING.
9. THE CHOICE OF THE SUPPORT SECTION TYPE OF DESIGN TO BE APPLIED IS BASED ON GEOMECHANICAL CONDITIONS AT TUNNEL FACE DEFINED BY FACE MAPPING. EACH SECTION TYPE HAS A SPECIFIC FIELD OF APPLICATION BASED ON DEFINED GEOMECHANICAL CONDITIONS. THE SUPPORT VARIABILITY INCLUDED IN EACH SUPPORT SECTION TYPE IS MANAGED ON SITE ON THE BASIS OF VISUAL INSPECTION, EXCAVATION BEHAVIOUR AND MONITORING RESULTS BY THE DESIGN REPRESENTATIVE.



Originator

TheArabContractors OSMAN AHMAD OSMAN & CO. المقاولون العرب شركة عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

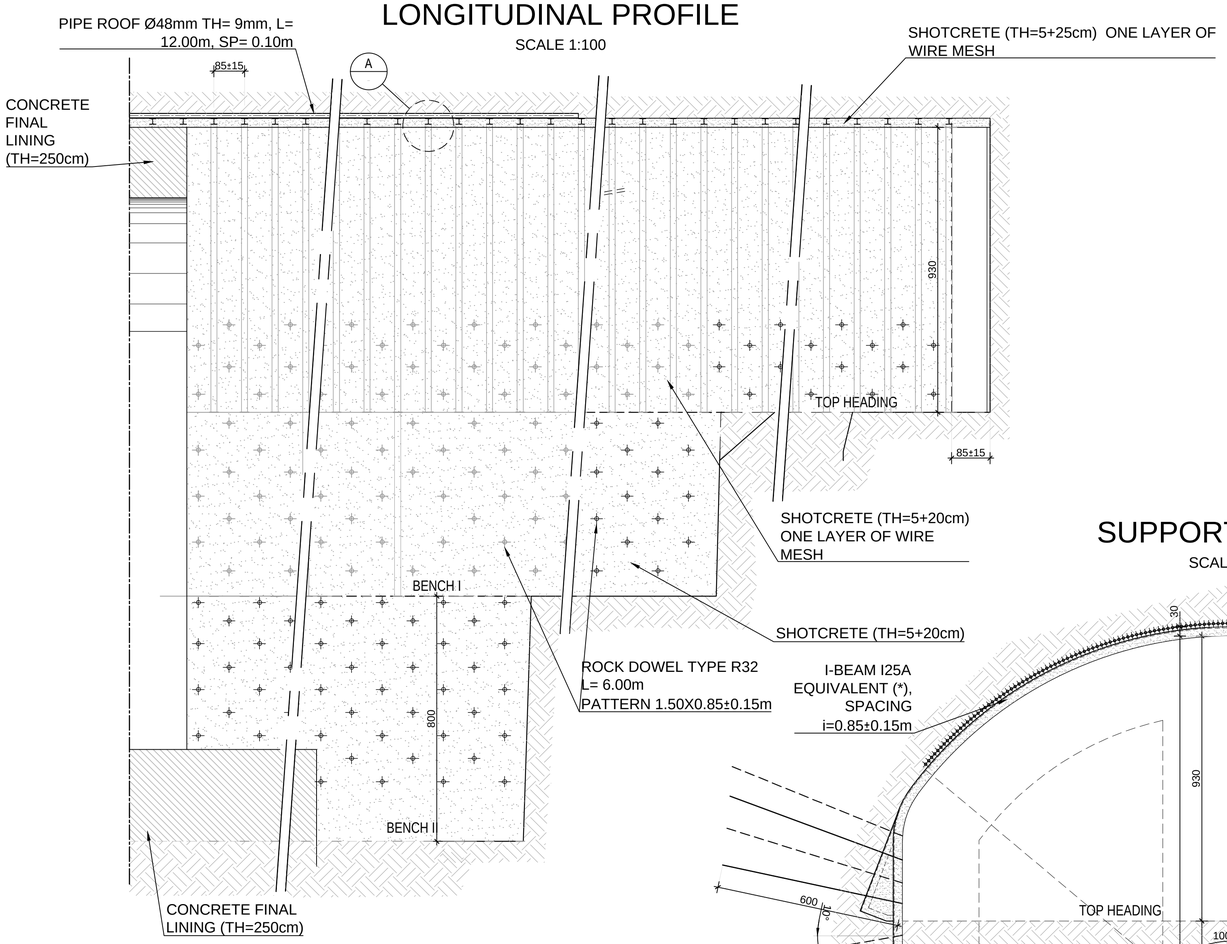
DIVERSION TUNNEL - Primary Support
Typical Cross Section for Transition Zone (Type A - upstream) - Support type Fa

Detail Design

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Document no. RUF-SHC330-ULX-&CTA010-001002	Rev. 00	PAGE NO. 03

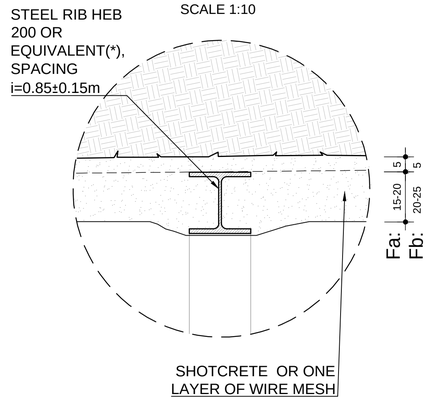
LONGITUDINAL PROFILE

SCALE 1:100



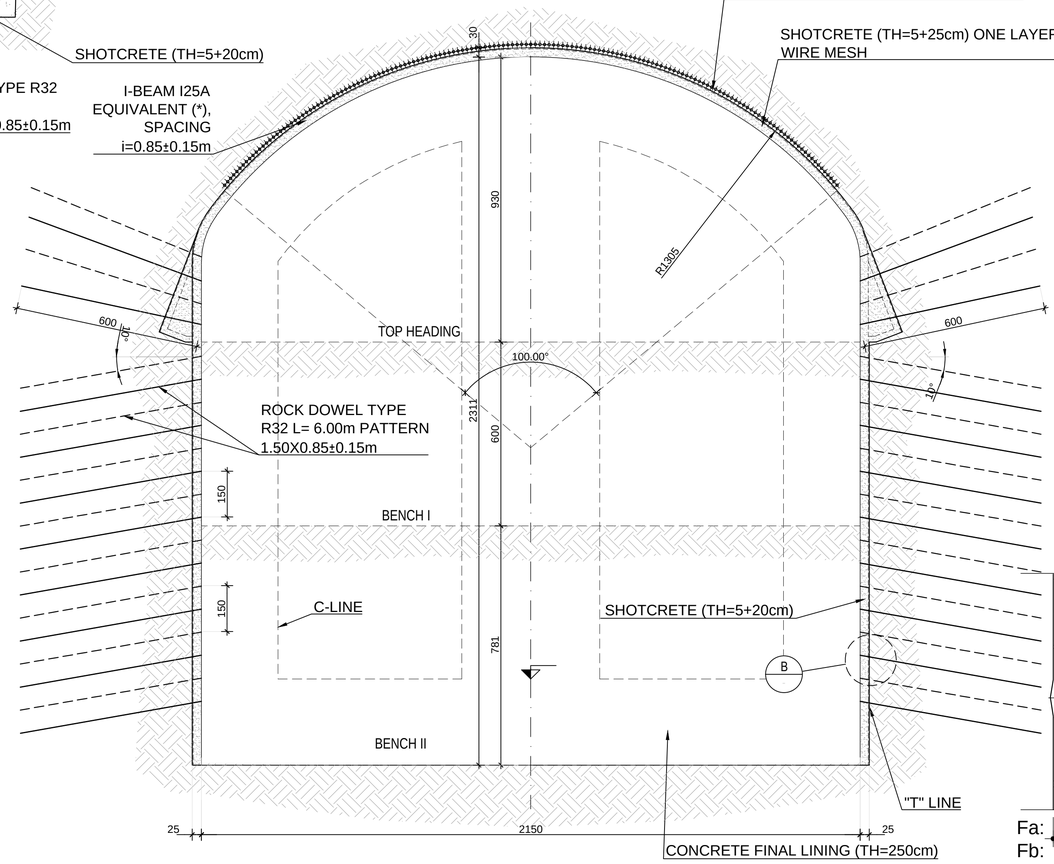
DETAIL "A"

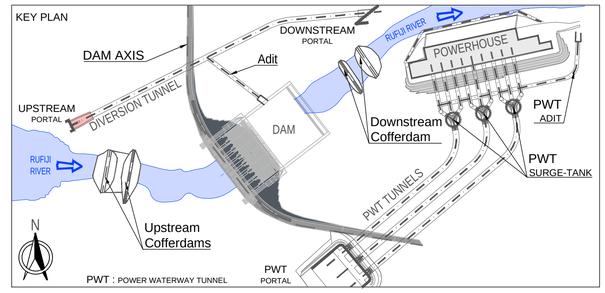
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SUPPORT TYPE Fb

SCALE 1:100





GENERAL NOTES:

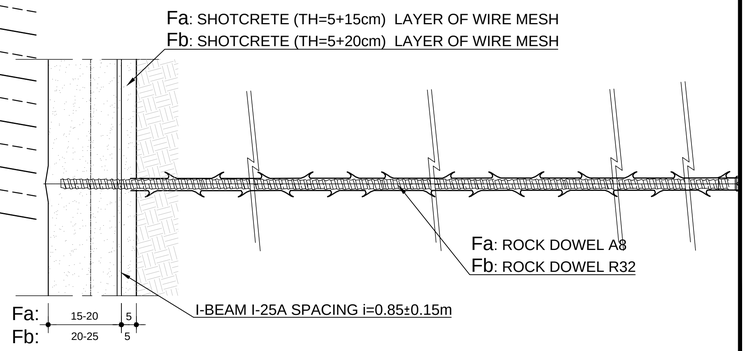
1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE FINAL LINING SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, ROCK DOWEL AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED.
4. WATER INFLOW EVALUATION DURING CONSTRUCTION WILL ALLOW TO CONFIRM THE PRESENCE OF DRAINAGE SYSTEM AND/OR TO OPTIMIZE THE NUMBER, LENGTH OF DRAINS AND OVERLAPP. WATER FROM ROCK MASS COLLECTED BY DRAINS MUST BE CHANNELIZED IN DRAINAGE TRENCHES.
5. SUPPORT MEASURES ARE DESIGNED ACCORDING TO AVAILABLE GEOLOGICAL DATA, TO BE VERIFIED ON SITE DURING CONSTRUCTION.
6. TO ENSURE SAFETY FIRST MIN 30mm OF SHOTCRETE SHALL BE INSTALLED ON ALL EXPOSED SURFACE IMMEDIATELY AFTER EXCAVATION.
7. TYPICAL APPLICATION RANGE OF RMR : 15<RMR<20 (Fa) AND RMR<15 (Fb).
8. THE ARRANGEMENT OF TOP HEADING MULTI DRIFT AND BENCHING EXCAVATION WILL BE CONFIRMED OR OPTIMIZED BY THE CONTRACTOR ACCORDING TO THEIR AVAILABLE EQUIPMENT AND PREFERRED SOLUTIONS. ACCORDING TO THE DESIGN SOLUTION, ADDITIONAL SUPPORTS SHALL BE INSTALLED ALONG THE TEMPORARY LATERAL SIDEWALLS (I.E. ADDITIONAL SHOTCRETE LAYER WITH ROCK DOWEL AND STEEL RIB ARCH WHERE REQUIRED) TO ENSURE SAFE CONDITIONS DURING.
9. THE CHOICE OF THE SUPPORT SECTION TYPE OF DESIGN TO BE APPLIED IS BASED ON GEOMECHANICAL CONDITIONS AT TUNNEL FACE DEFINED BY FACE MAPPING. EACH SECTION TYPE HAS A SPECIFIC FIELD OF APPLICATION BASED ON DEFINED GEOMECHANICAL CONDITIONS. THE SUPPORT VARIABILITY INCLUDED IN EACH SUPPORT SECTION TYPE IS MANAGED ON SITE ON THE BASIS OF VISUAL INSPECTION, EXCAVATION BEHAVIOUR AND MONITORING RESULTS BY THE DESIGN REPRESENTATIVE.

0 10 20 50cm
GRAPHIC SCALE 1:10

0 1 2 5m
GRAPHIC SCALE 1:100

DETAIL "B"

SCALE 1:10



Originator

The Arab Contractors OSMAN AHMAD OSMAN & CO. المقاولون العرب حسان أحمد حسان وشركاه

ELSEWEDY ELECTRIC

Title

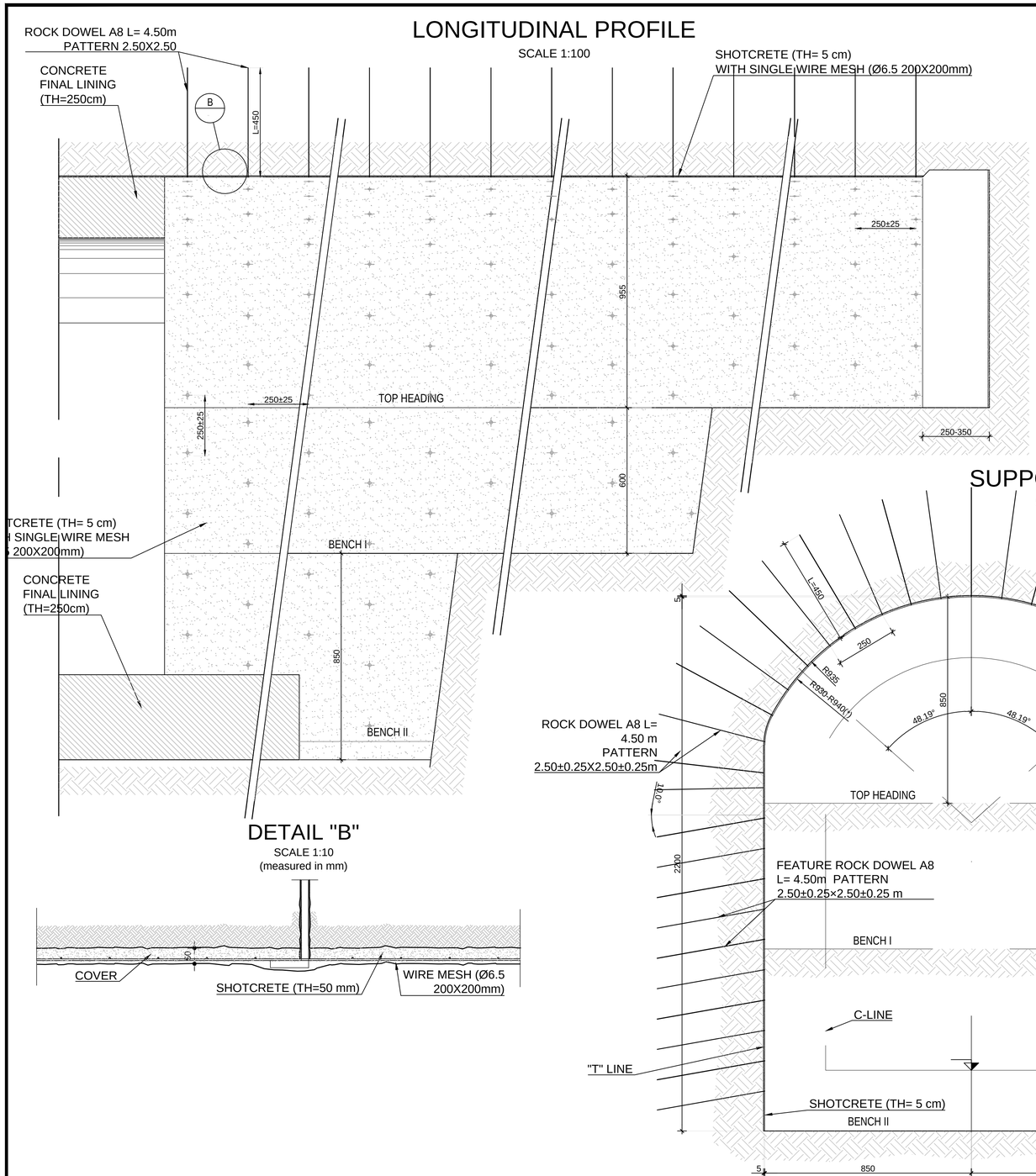
DIVERSION TUNNEL - Primary Support
Typical Cross Section for Transition Zone (Type A - upstream) - Support type Fb

Detail Design

Type: BLACK	Scale: As Shown	Size: A3
Document no. RUF-SHC330-ULX-&CTA010-001002	Rev. 00	PAGE NO. 04

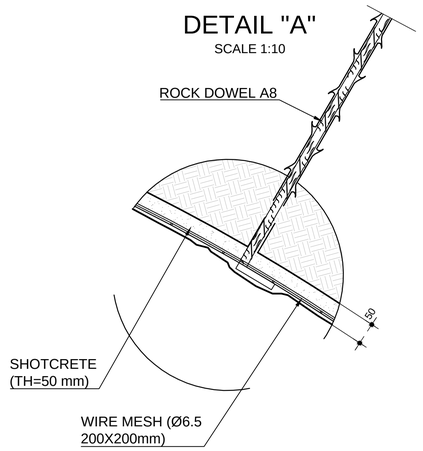
LONGITUDINAL PROFILE

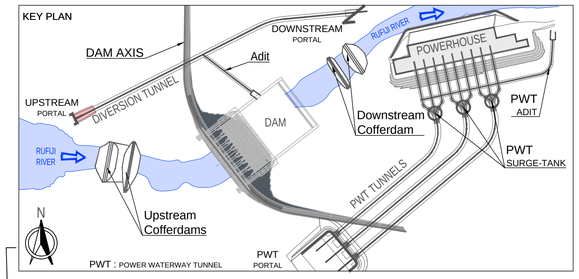
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DETAIL "A"

SCALE 1:10





GENERAL NOTES:

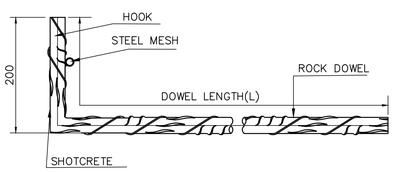
1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE FINAL LINING SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, ROCK DOWEL AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED.
4. WATER INFLOW EVALUATION DURING CONSTRUCTION WILL ALLOW TO CONFIRM THE PRESENCE OF DRAINAGE SYSTEM AND/OR TO OPTIMIZE THE NUMBER, LENGTH OF DRAINS AND OVERLAPP. WATER FROM ROCK MASS COLLECTED BY DRAINS MUST BE CHANNELIZED IN DRAINAGE TRENCHES.
5. SUPPORT MEASURES ARE DESIGNED ACCORDING TO AVAILABLE GEOLOGICAL DATA, TO BE VERIFIED ON SITE DURING CONSTRUCTION.
6. SHOTCRETE THICKNESS MUST BE INCREASED LOCALLY TO ENSURE MIN 30mm LATTICE GIRDER COVER FOR PROTECTION AGAINST CORROSION.
7. THE ARRANGEMENT OF TOP HEADING MULTI DRIFT AND BENCHING EXCAVATION WILL BE CONFIRMED OR OPTIMIZED BY THE CONTRACTOR ACCORDING TO THEIR AVAILABLE EQUIPMENT AND PREFERRED SOLUTIONS. ACCORDING TO THE DESIGN SOLUTION, ADDITIONAL SUPPORTS SHALL BE INSTALLED ALONG THE TEMPORARY LATERAL SIDEWALLS (I.E. ADDITIONAL SHOTCRETE LAYER WITH ROCK DOWEL AND STEEL RIB ARCH WHERE REQUIRED) TO ENSURE SAFE CONDITIONS
8. THE CHOICE OF THE SUPPORT SECTION TYPE OF DESIGN TO BE APPLIED IS BASED ON GEOMECHANICAL CONDITIONS AT TUNNEL FACE DEFINED BY FACE MAPPING. EACH SECTION TYPE HAS A SPECIFIC FIELD OF APPLICATION BASED ON DEFINED GEOMECHANICAL CONDITIONS. THE SUPPORT VARIABILITY INCLUDED IN EACH SUPPORT SECTION TYPE IS MANAGED ON SITE ON THE BASIS OF VISUAL INSPECTION, EXCAVATION BEHAVIOUR AND MONITORING RESULTS BY THE DESIGN REPRESENTATIVE.
9. SUPPORT B COULD BE APPLIED ONLY AFTER 20/25M OF DIVERSION TUNNEL UNDERGROUND EXCAVATION AND IF ROCK MASS QUALITY WILL BE IN THE RANGE OF 60<RMR<70.

SUPPORT TYPE B

SCALE 1:100

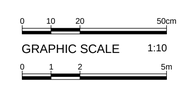
DETAIL "B"

SCALE 1:10
(measured in mm)



ROCK DOWEL

SCALE 1:5
(measured in mm)



Originator

TheArabContractors OSMAN AHMAD OSMAN & CO. المقاولون العرب حسان احمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

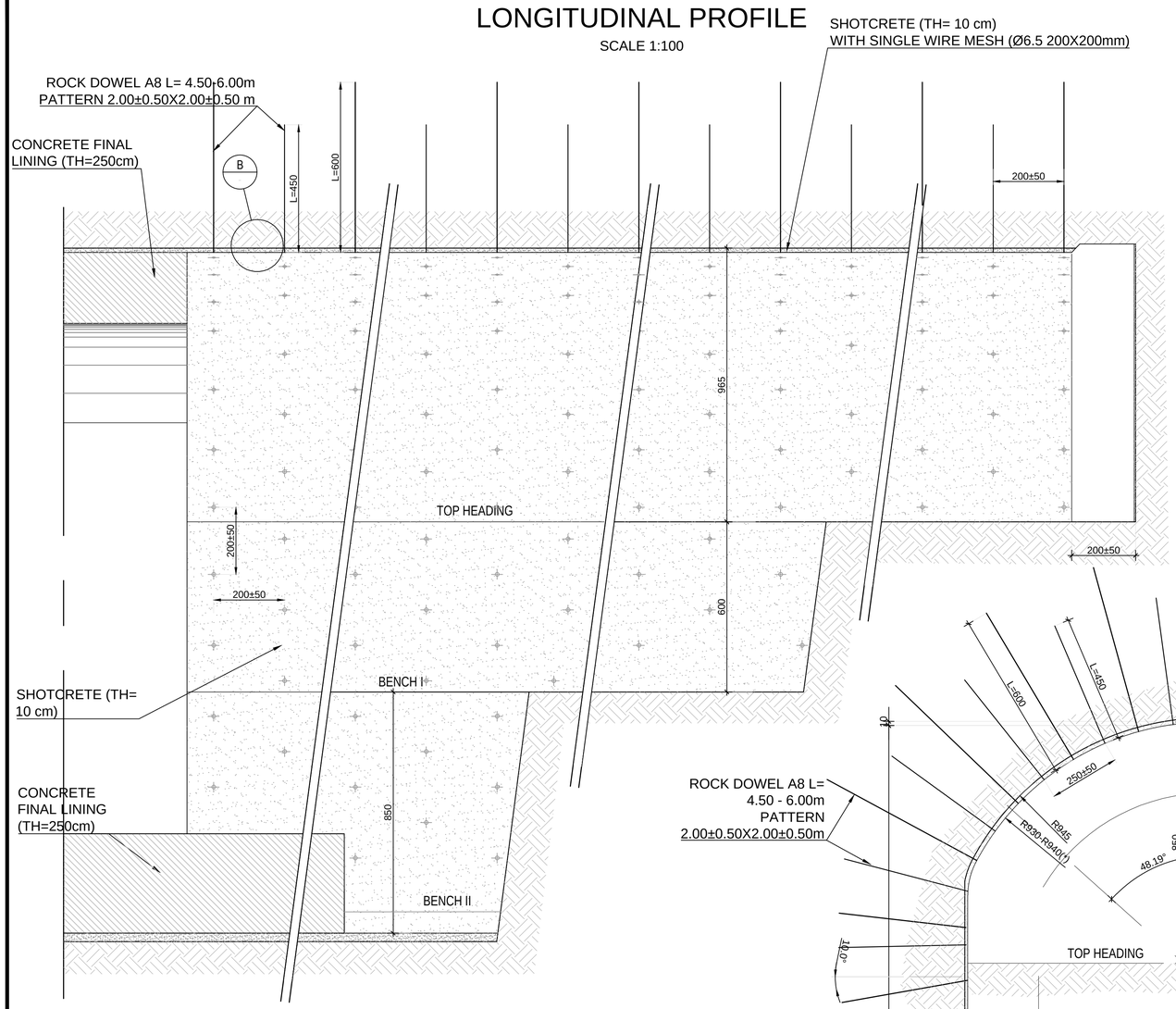
DIVERSION TUNNEL
Typical Cross Section for Transition Zone (Type A - upstream) - Support type B

Detail Design

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Document no. RUF-SHC330-ULX-&CTA010-001002	Rev. 00	PAGE NO. 05

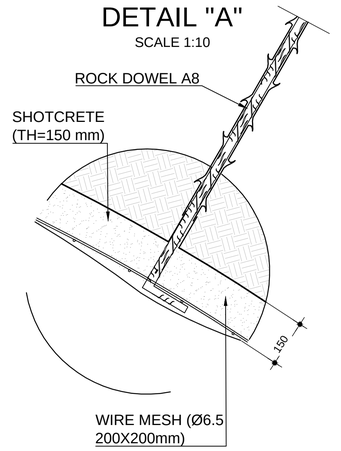
LONGITUDINAL PROFILE

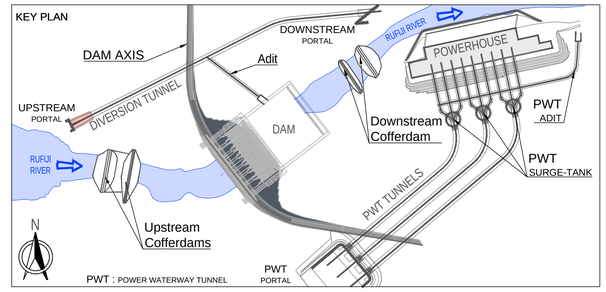
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DETAIL "A"

SCALE 1:10



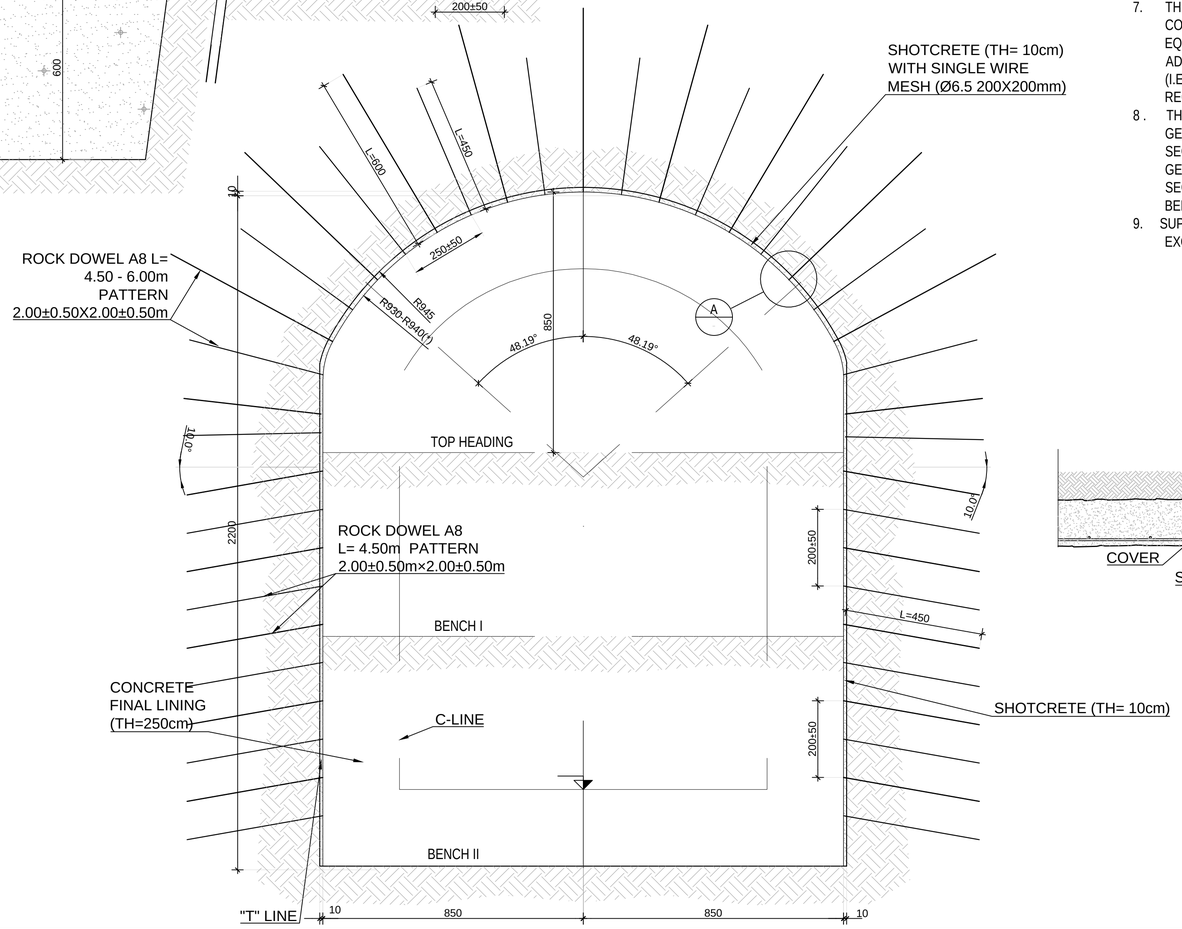


SUPPORT TYPE C1

SCALE 1:100

GRAPHIC SCALE 1:10

GRAPHIC SCALE 1:100

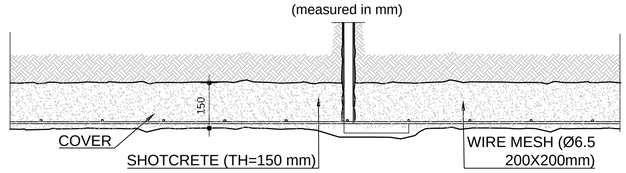


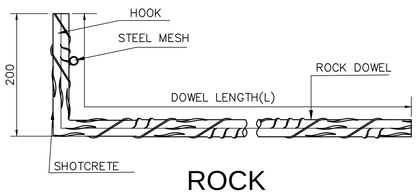
GENERAL NOTES:

1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE FINAL LINING SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, ROCK DOWEL AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED.
4. WATER INFLOW EVALUATION DURING CONSTRUCTION WILL ALLOW TO CONFIRM THE PRESENCE OF DRAINAGE SYSTEM AND/OR TO OPTIMIZE THE NUMBER, LENGTH OF DRAINS AND OVERLAPP. WATER FROM ROCK MASS COLLECTED BY DRAINS MUST BE CHANNELIZED IN DRAINAGE TRENCHES.
5. SUPPORT MEASURES ARE DESIGNED ACCORDING TO AVAILABLE GEOLOGICAL DATA, TO BE VERIFIED ON SITE DURING CONSTRUCTION.
6. SHOTCRETE THICKNESS MUST BE INCREASED LOCALLY TO ENSURE MIN 30mm LATTICE GIRDER COVER FOR PROTECTION AGAINST CORROSION.
7. THE ARRANGEMENT OF TOP HEADING MULTI DRIFT AND BENCHING EXCAVATION WILL BE CONFIRMED OR OPTIMIZED BY THE CONTRACTOR ACCORDING TO THEIR AVAILABLE EQUIPMENT AND PREFERRED SOLUTIONS. ACCORDING TO THE DESIGN SOLUTION, ADDITIONAL SUPPORTS SHALL BE INSTALLED ALONG THE TEMPORARY LATERAL SIDEWALLS (I.E. ADDITIONAL SHOTCRETE LAYER WITH ROCK DOWEL AND STEEL RIB ARCH WHERE REQUIRED) TO ENSURE SAFE CONDITIONS
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9. SUPPORT C COULD BE APPLIED ONLY AFTER 20/25M OF DIVERSION TUNNEL UNDERGROUND EXCAVATION AND IF ROCK MASS QUALITY WILL BE IN THE RANGE OF 40<RMR<60.

DETAIL "B"

SCALE 1:10
(measured in mm)





ROCK DOWEL

SCALE 1:5

Originator

The Arab Contractors OSMAN AHMAD OSMAN & CO.
ELSEWEDY ELECTRIC

Title

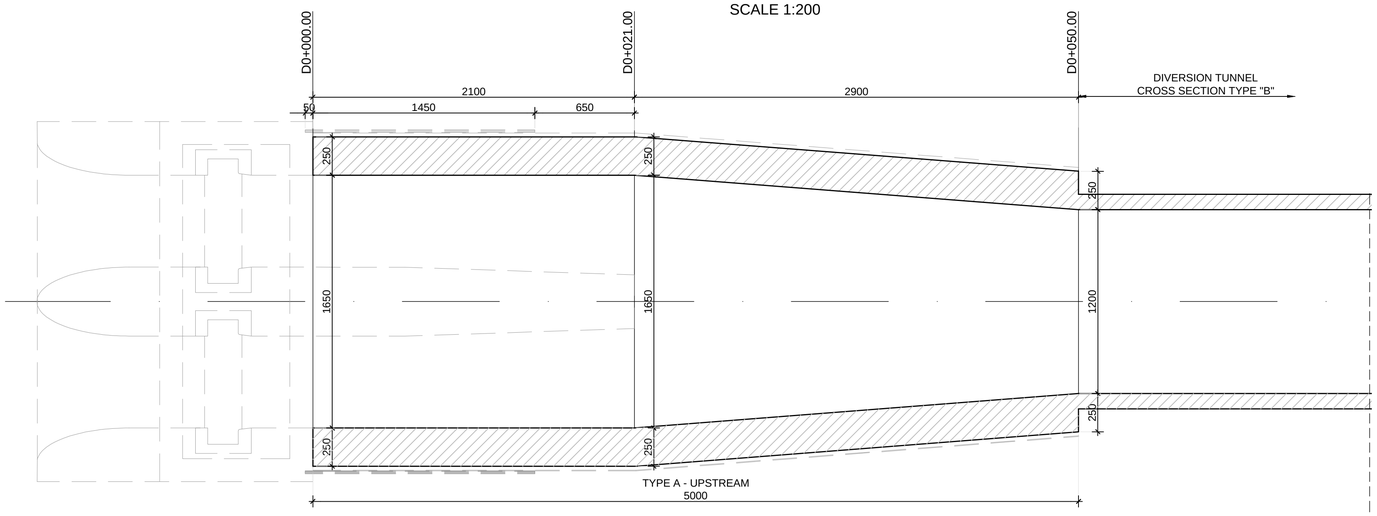
DIVERSION TUNNEL
Typical Cross Section for Transition Zone (Type A - upstream) - Support type C1

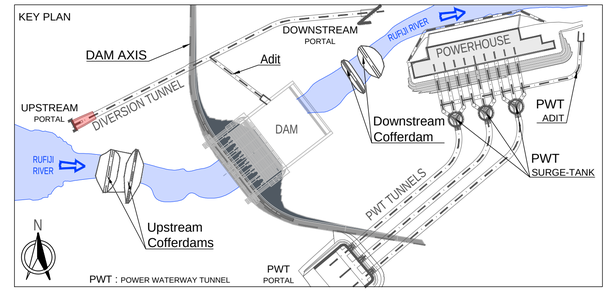
Detail Design

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Document no. RUF-SHC330-ULX-&CTA010-001002	Rev. 00	PAGE NO. 06

PLAN VIEW

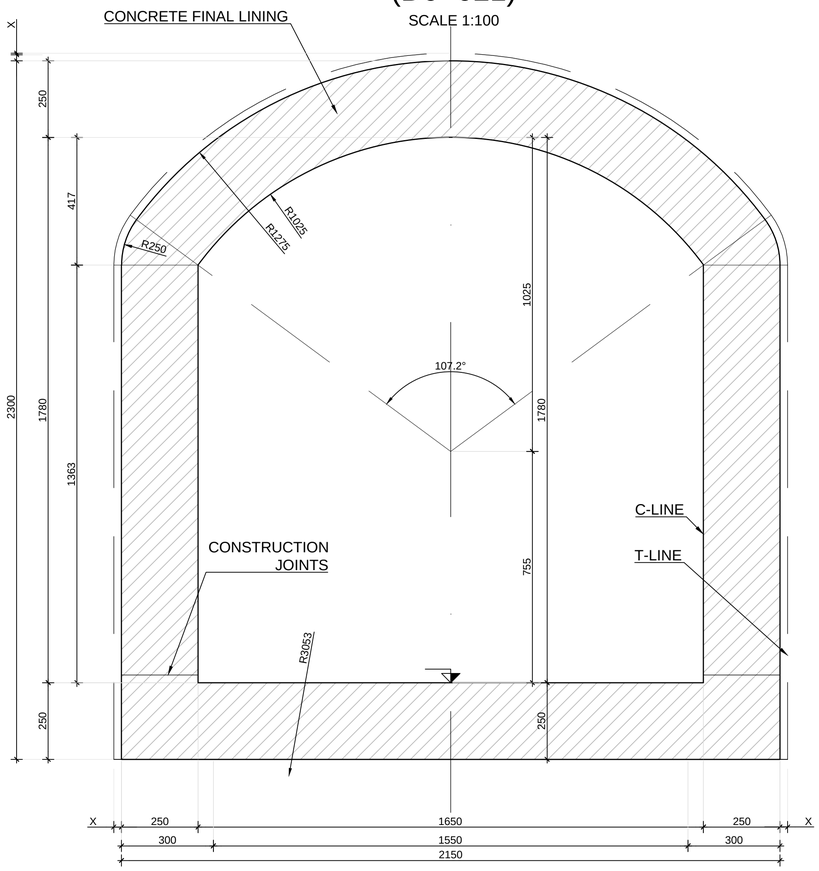
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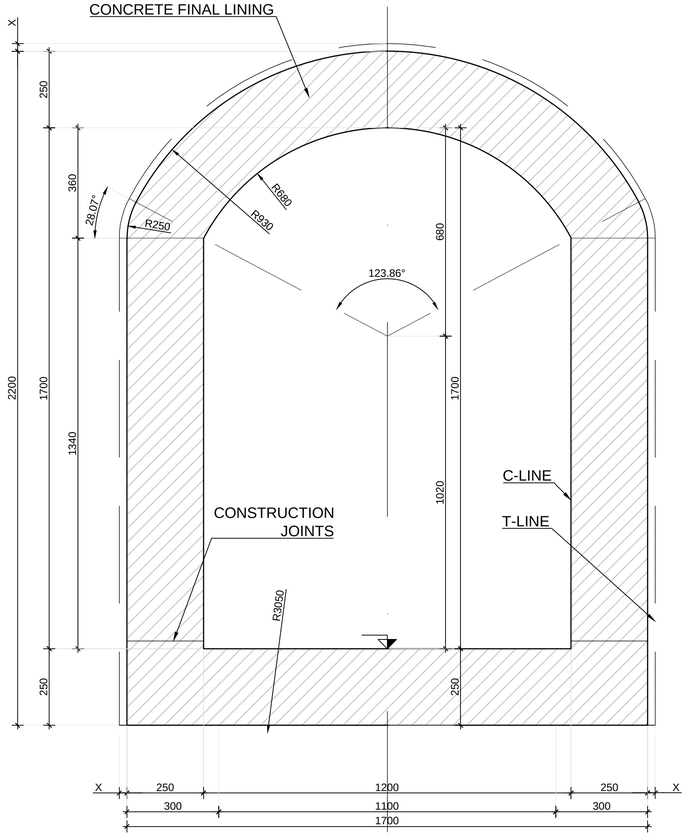
FINAL LINING (D0+021)

SCALE 1:100



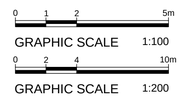
FINAL LINING (D0+050)

SCALE 1:100



GENERAL NOTES:

1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE FINAL LINING SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED



Originator

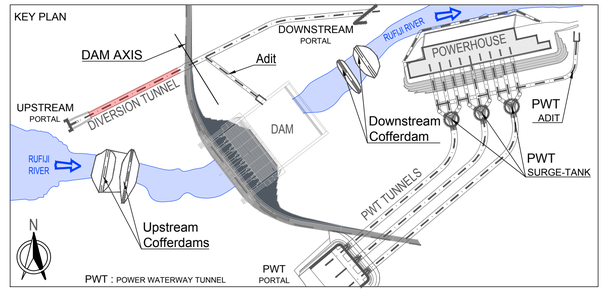
The Arab Contractors
OSMAN AHMAD OSMAN & CO.
ELSEWEDY ELECTRIC

Title

Detail Design

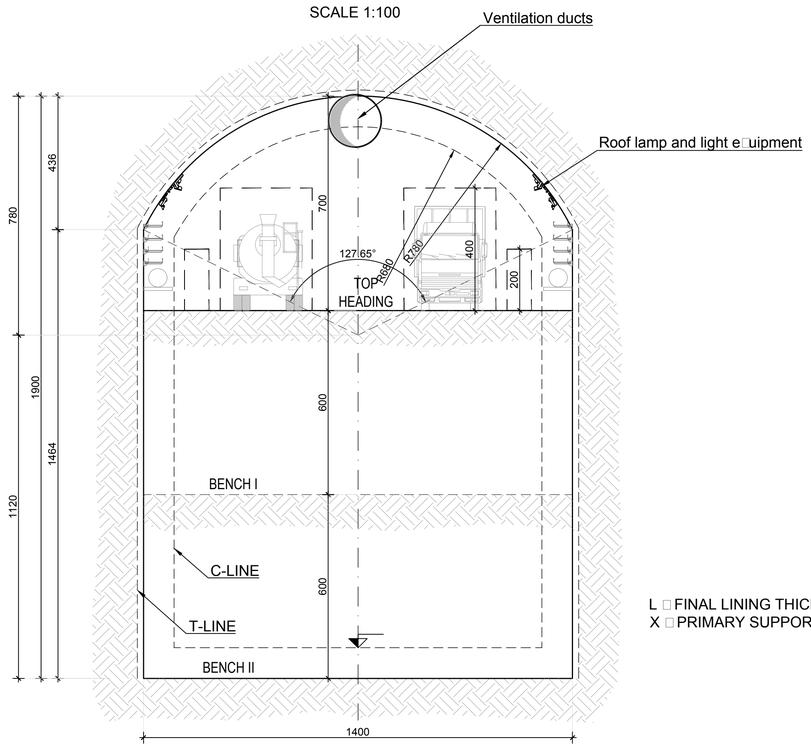
DIVERSION TUNNEL
Final lining geometry Cross Section
for Transition Zone (Type A-upstream) Support type C2

Type: BLACK	Scale: As Shown	Size: A3
Document no. RUF-SHC330-ULX-&CTA010-001002	Rev. 00	PAGE NO. 07



TEMPORARY WORKS FOR SUPPORT TYPE B-F2

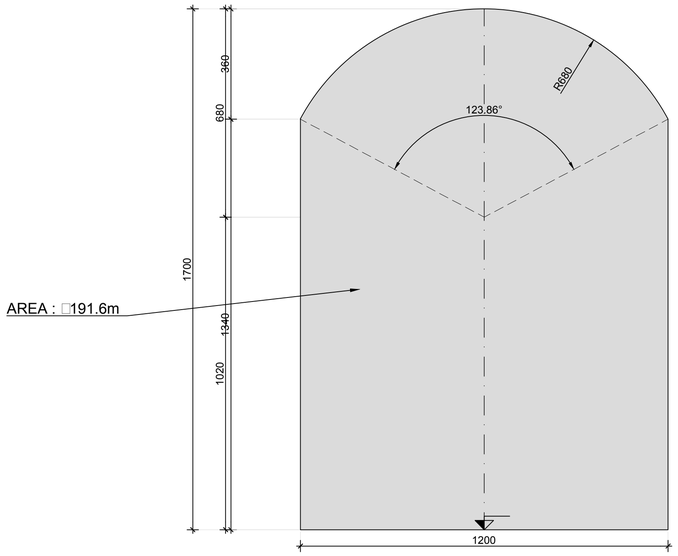
SCALE 1:100



L : FINAL LINING THICKNESS
X : PRIMARY SUPPORT THICKNESS

OPERATIONAL WORKS HYDRAULIC CLEARANCE

SCALE 1:100



GENERAL NOTES:

1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
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4. THE ARRANGEMENT OF TOP HEADING MULTI DRIFT AND BENCHING EXCAVATION WILL BE CONFIRMED OR OPTIMIZED BY THE CONTRACTOR ACCORDING TO THEIR AVAILABLE EQUIPMENT AND PREFERRED SOLUTIONS



Originator

The Arab Contractors — Osman Ahmad Osman & Co. — المقاولون العرب — عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

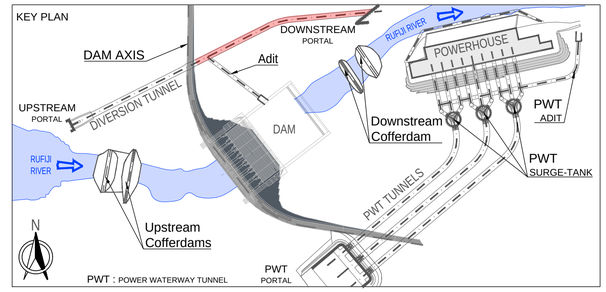
Detail Design

DIVERSION TUNNEL

Typical Cross Section for the Upstream stretch (Type B)

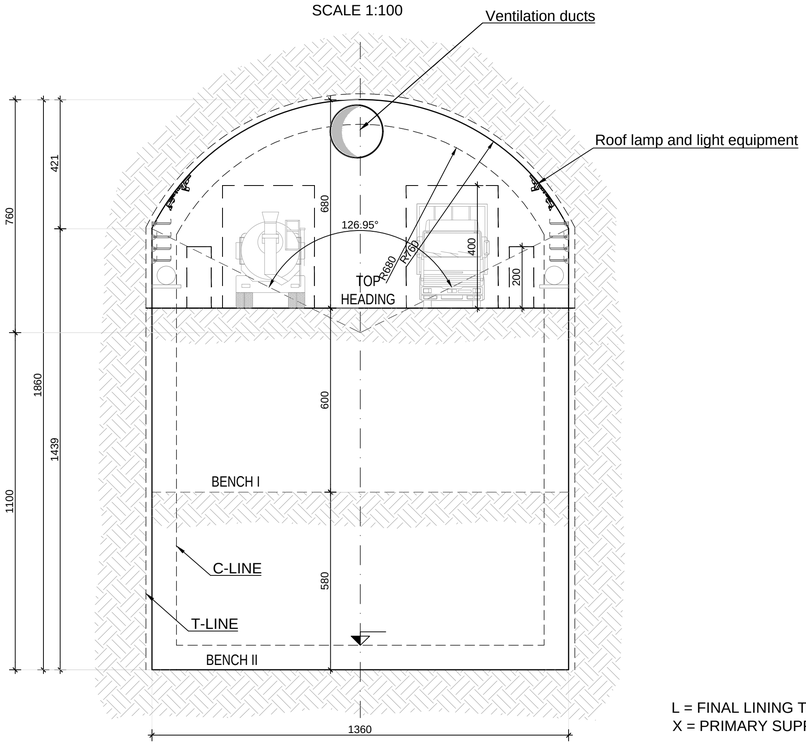
Operational & temporary works

Type: BLACK	Scale: As Shown	Size: A3
Document no. RUF-SHC330-ULX-&CTA010-001003	Rev. 00	PAGE NO. 01



TEMPORARY WORKS FOR SUPPORT TYPE B-F2

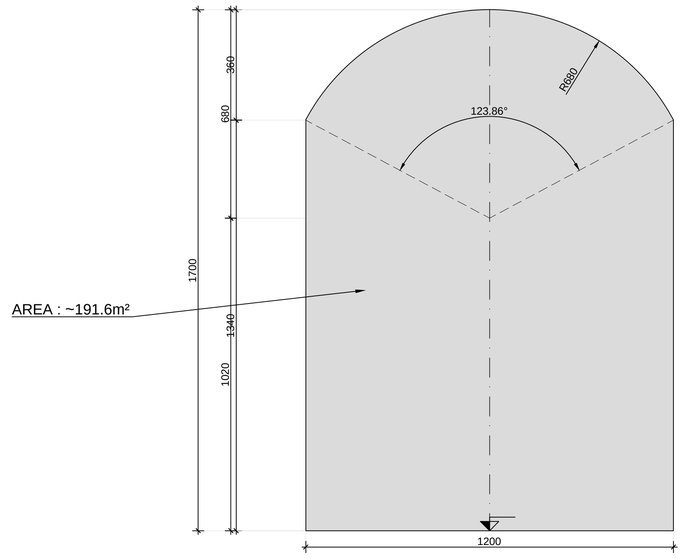
SCALE 1:100



L = FINAL LINING THICKNESS
X = PRIMARY SUPPORT THICKNESS

OPERATIONAL WORKS HYDRAULIC CLEARANCE

SCALE 1:100



GENERAL NOTES:

1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
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4. THE ARRANGEMENT OF TOP HEADING MULTI DRIFT AND BENCHING EXCAVATION WILL BE CONFIRMED OR OPTIMIZED BY THE CONTRACTOR ACCORDING TO THEIR AVAILABLE EQUIPMENT AND PREFERRED SOLUTIONS



Originator

TheArabContractors OSMAN AHMAD OSMAN & CO. المقاولون العرب عثمان أحمد عثمان وشركاه

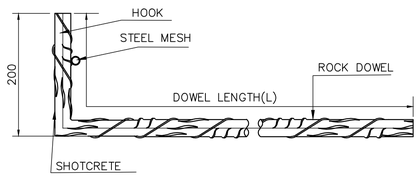
ELSEWEDY ELECTRIC

Title

Detail Design

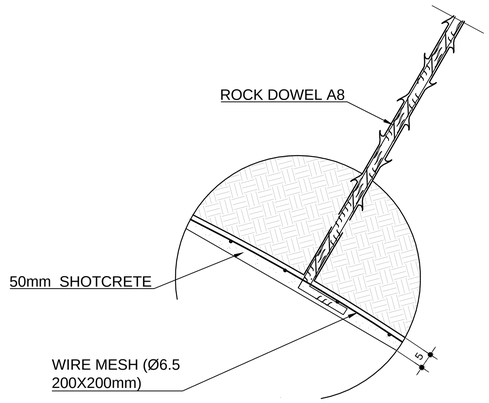
DIVERSION TUNNEL
Typical Cross Section for the Downstream stretch (Type C)
Operational & temporary works

Type: BLACK	Scale: As Shown	Size: A3
Document no. RUF-SHC330-ULX-&CTA010-001003	Rev. 00	PAGE NO. 02



ROCK DOWEL

SCALE 1:5
(measured in mm)

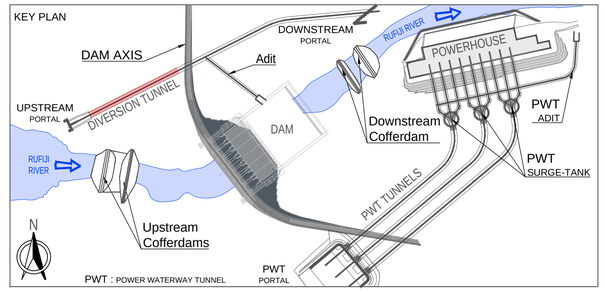


DETAIL "A"

SCALE 1:10

GENERAL NOTES:

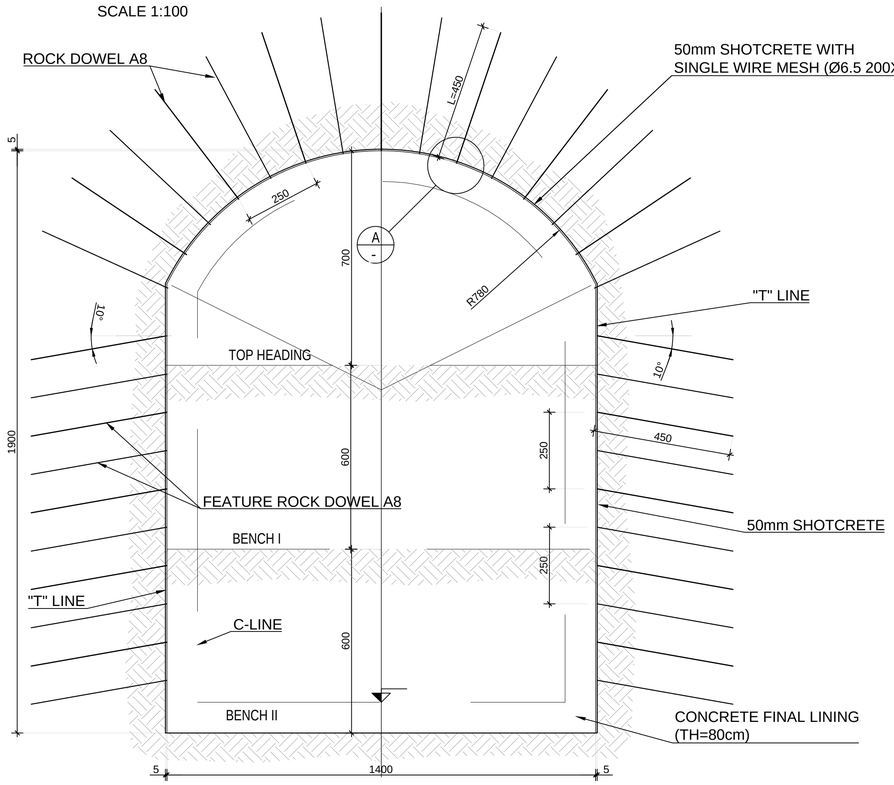
1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
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5. SUPPORT MEASURES ARE DESIGNED ACCORDING TO AVAILABLE GEOLOGICAL DATA, TO BE VERIFIED ON SITE DURING CONSTRUCTION.
6. TYPICAL APPLICATION RANGE OF RMR : >60.
7. THE ARRANGEMENT OF TOP HEADING MULTI DRIFT AND BENCHING EXCAVATION WILL BE CONFIRMED OR OPTIMIZED BY THE CONTRACTOR ACCORDING TO THEIR AVAILABLE EQUIPMENT AND PREFERRED SOLUTIONS. ACCORDING TO THE DESIGN SOLUTION, ADDITIONAL SUPPORTS SHALL BE INSTALLED ALONG THE TEMPORARY LATERAL SIDEWALLS (I.E. ADDITIONAL SHOTCRETE LAYER WITH ROCK DOWEL AND STEEL RIB ARCH WHERE REQUIRED) TO ENSURE SAFE CONDITIONS DURING.
8. FOR SPECIFIC NOTES REFER TO DRAWING RUFIJI-SHC-ULU-CLH060-00-6/8
9. THE CHOICE OF THE SUPPORT SECTION TYPE OF DESIGN TO BE APPLIED IS BASED ON GEOMECHANICAL CONDITIONS AT TUNNEL FACE DEFINED BY FACE MAPPING. EACH SECTION TYPE HAS A SPECIFIC FIELD OF APPLICATION BASED ON DEFINED GEOMECHANICAL CONDITIONS. THE SUPPORT VARIABILITY INCLUDED IN EACH SUPPORT SECTION TYPE IS MANAGED ON SITE ON THE BASIS OF VISUAL INSPECTION, EXCAVATION BEHAVIOUR AND MONITORING RESULTS BY THE DESIGN REPRESENTATIVE.



EXACAVATION METHOD	PRIMARY SUPPORT TYPE B Range of application: 60≤RMR & 4.64≤Q
TOP-HEADING & BENCHING EXCAVATION	ROUND LENGHT: 2.50-3.50m
	50mm SHOTCRETE WITH SINGLE WIRE MESH (ϕ6.5 200X200mm) IN THE CROWN AND 50mm SHOTCRETE IN THE SIDEWAY
	SYSTEMATIC ROCK DOWEL A8 PATTERN 2.5×2.5m IN THE CROWN AND FEARURE ROCK DOWEL A8 PATTERN 2.5×2.5m IN THE SIDEWALLS, ROCK DOWEL A8 WITH Fy≥200KN (DIA.25mm MIN), L=4.5m

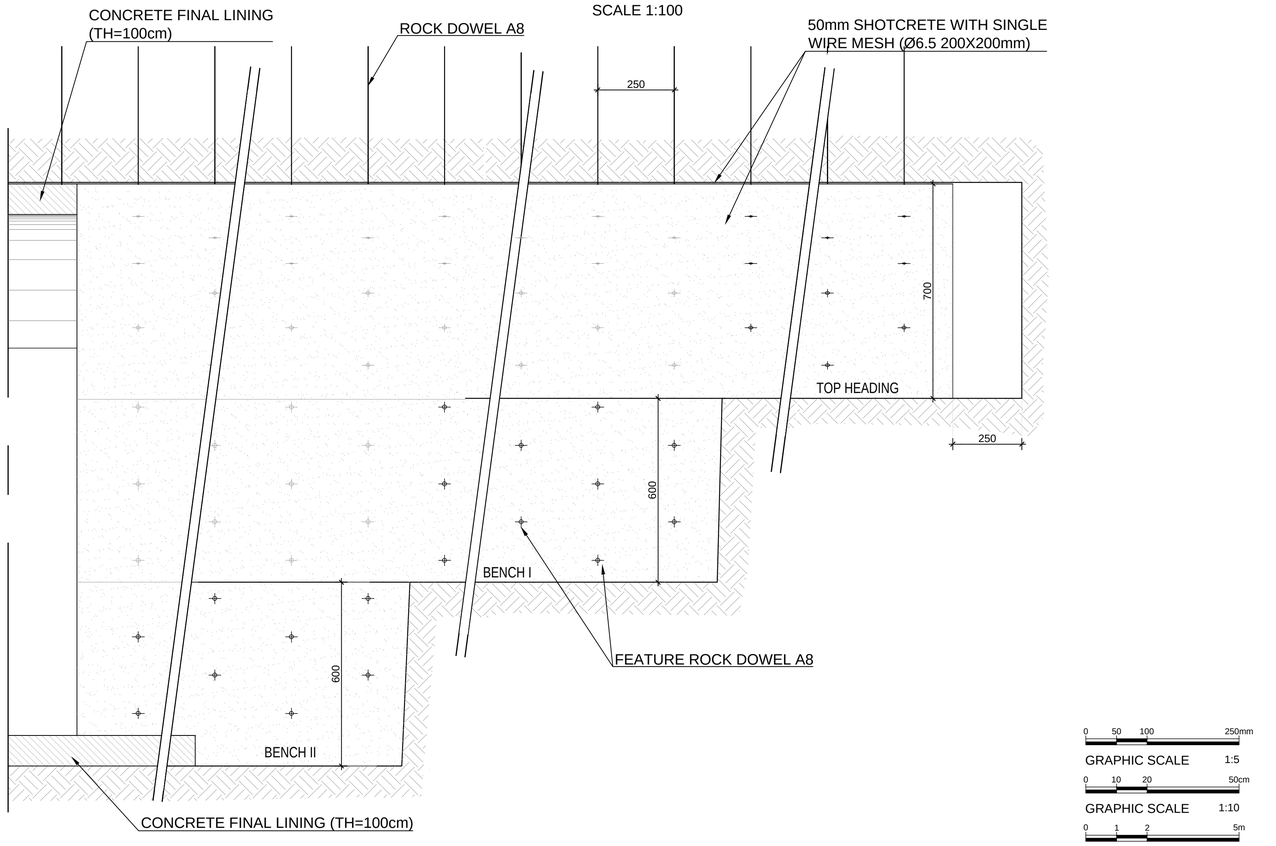
SUPPORT TYPE B

SCALE 1:100



LONGITUDINAL PROFILE

SCALE 1:100



Originator

The Arab Contractors
OSMAN AHMAD OSMAN & CO.
المقاولون العرب
عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

DIVERSION TUNNEL
Primary Support
Upstream Cross Section (Type B) Support type B

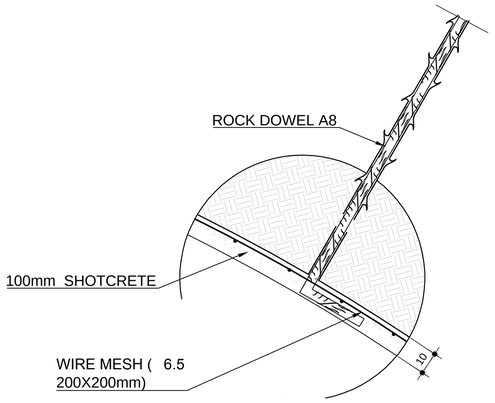
Detail Design

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Document no.	Rev.	PAGE NO.
RUF-SHC330-ULX-&CTA010-001003	Rev. 00	03

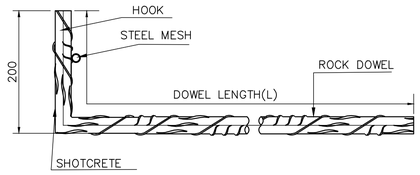
GENERAL NOTES:

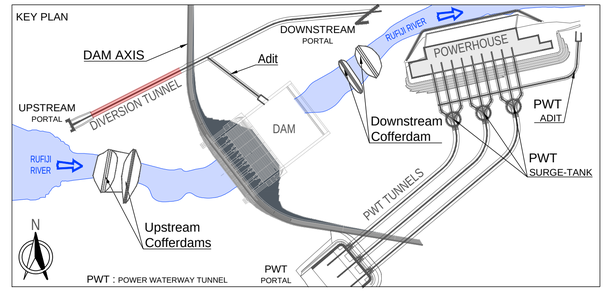
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5. SUPPORT MEASURES ARE DESIGNED ACCORDING TO AVAILABLE GEOLOGICAL DATA, TO BE VERIFIED ON SITE DURING CONSTRUCTION.
6. TYPICAL APPLICATION RANGE OF RMR : 40-60.
7. THE ARRANGEMENT OF TOP HEADING MULTI DRIFT AND BENCHING EXCAVATION WILL BE CONFIRMED OR OPTIMIZED BY THE CONTRACTOR ACCORDING TO THEIR AVAILABLE EQUIPMENT AND PREFERRED SOLUTIONS. ACCORDING TO THE DESIGN SOLUTION, ADDITIONAL SUPPORTS SHALL BE INSTALLED ALONG THE TEMPORARY LATERAL SIDEWALLS (I.E. ADDITIONAL SHOTCRETE LAYER WITH ROCK DOWEL AND STEEL RIB ARCH WHERE REQUIRED) TO ENSURE SAFE CONDITIONS DURING.
8. THE CHOICE OF THE SUPPORT SECTION TYPE OF DESIGN TO BE APPLIED IS BASED ON GEOMECHANICAL CONDITIONS AT TUNNEL FACE DEFINED BY FACE MAPPING. EACH SECTION TYPE HAS A SPECIFIC FIELD OF APPLICATION BASED ON DEFINED GEOMECHANICAL CONDITIONS. THE SUPPORT VARIABILITY INCLUDED IN EACH SUPPORT SECTION TYPE IS MANAGED ON SITE ON THE BASIS OF VISUAL INSPECTION, EXCAVATION BEHAVIOUR AND MONITORING RESULTS BY THE DESIGN REPRESENTATIVE.



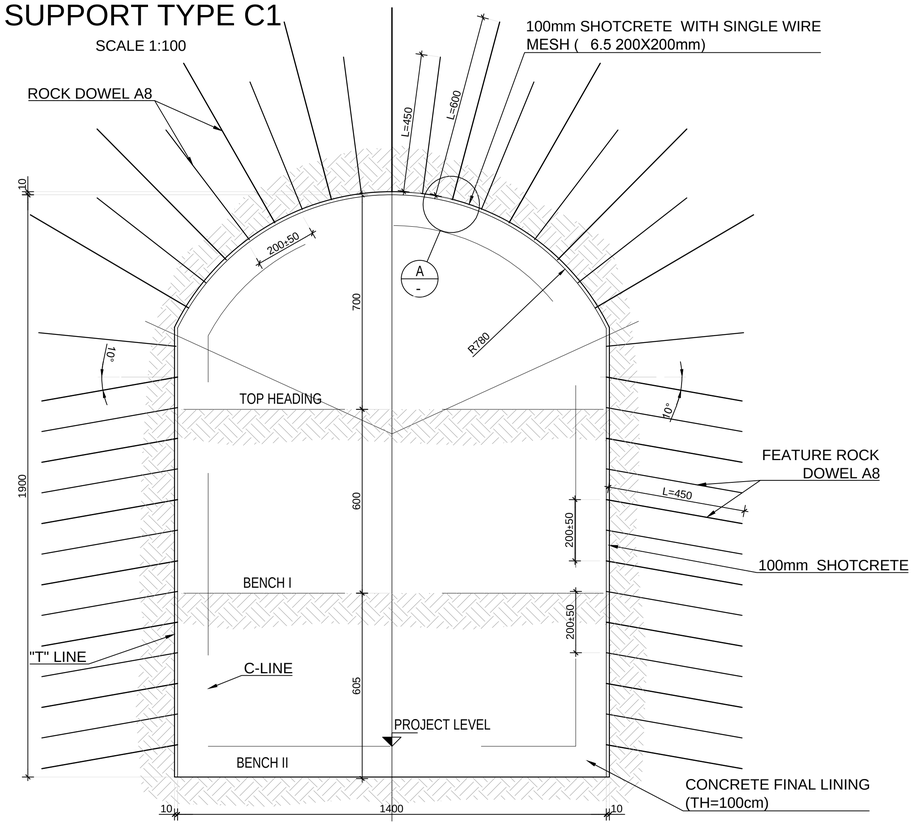
DETAIL "A"
SCALE 1:10

ROCK DOWEL
SCALE 1:5
(measured in mm)

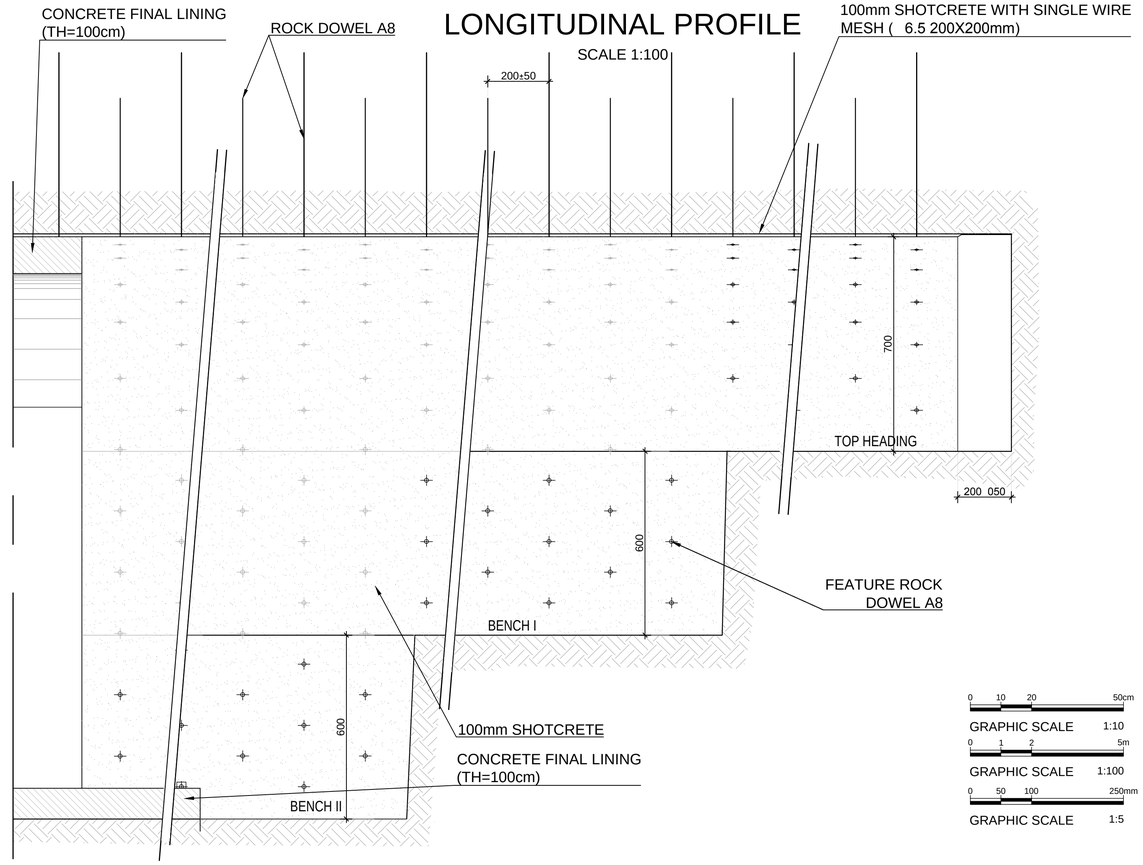




SUPPORT TYPE C1
SCALE 1:100



LONGITUDINAL PROFILE
SCALE 1:100



0 10 20 50cm
GRAPHIC SCALE 1:10
0 1 2 5m
GRAPHIC SCALE 1:100
0 50 100 250mm
GRAPHIC SCALE 1:5

Originator

The Arab Contractors
OSMAN AHMAD OSMAN & CO.
المقاولون العرب
عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

DIVERSION TUNNEL

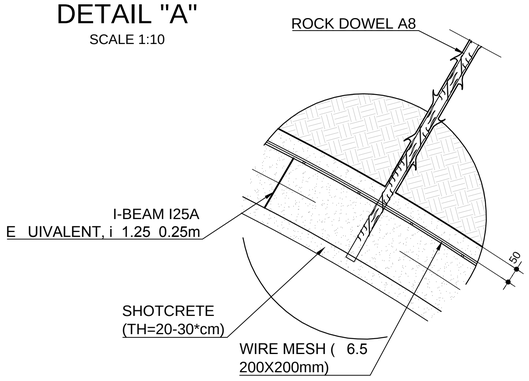
Primary Support
Upstream Cross Section (Type B) - Support type C1

Detail Design

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Document no. RUF-SHC330-ULX-&CTA010-001003	Rev. 00	PAGE NO. 04

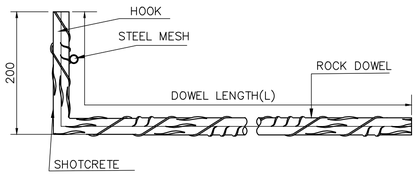
DETAIL "A"

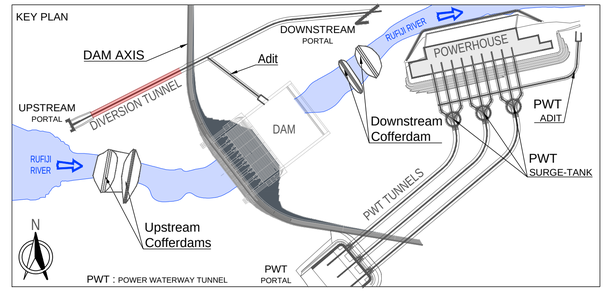
SCALE 1:10



ROCK DOWEL A8

SCALE 1:5
(measured in mm)



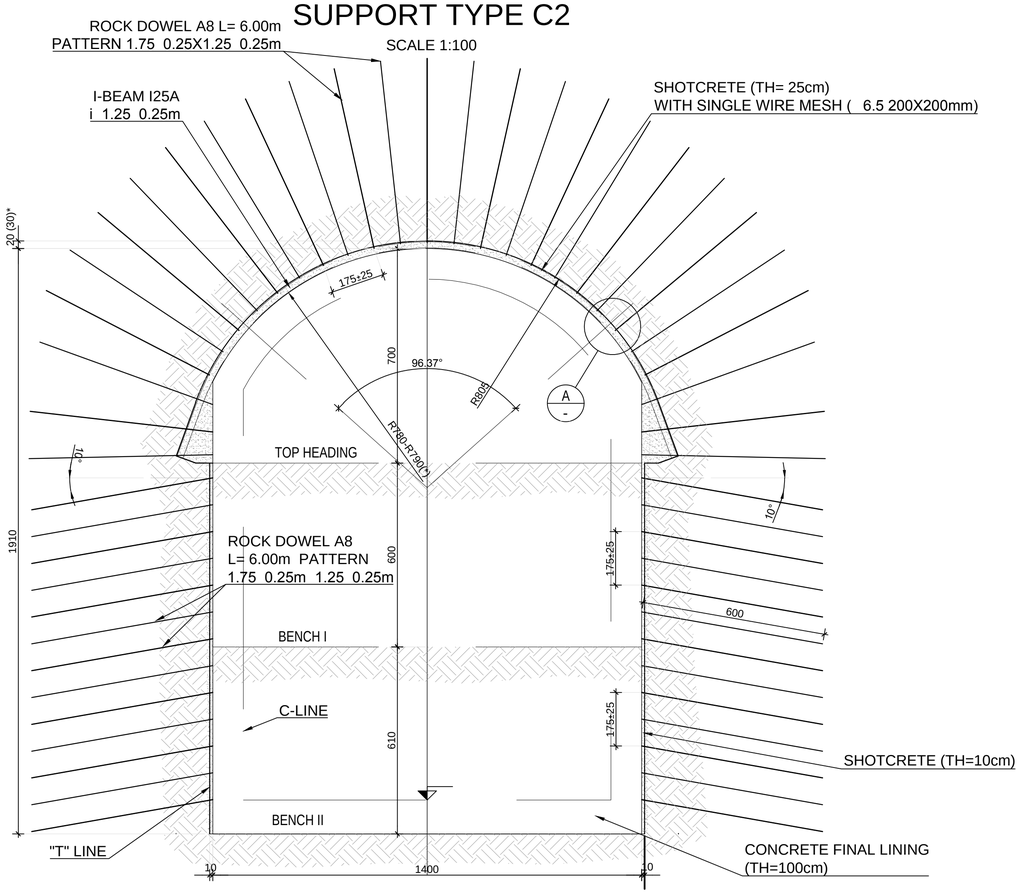


GENERAL NOTES:

1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE FINAL LINING SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, ROCK DOWEL AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED.
4. WATER INFLOW EVALUATION DURING CONSTRUCTION WILL ALLOW TO CONFIRM THE PRESENCE OF DRAINAGE SYSTEM AND/OR TO OPTIMIZE THE NUMBER, LENGTH OF DRAINS AND OVERLAPP. WATER FROM ROCK MASS COLLECTED BY DRAINS MUST BE CHANNELIZED IN DRAINAGE TRENCHES.
5. SUPPORT MEASURES ARE DESIGNED ACCORDING TO AVAILABLE GEOLOGICAL DATA, TO BE VERIFIED ON SITE DURING CONSTRUCTION.
6. SHOTCRETE THICKNESS MUST BE INCREASED LOCALLY TO ENSURE MIN 30mm LATTICE GIRDER COVER FOR PROTECTION AGAINST CORROSION.
7. 7.TO ENSURE SAFETY FIRST MIN 30mm OF SHOTCRETE SHALL BE INSTALLED ON ALL EXPOSED SURFACE IMMEDIATELY AFTER EXCAVATION.
5. TYPICAL APPLICATION RANGE OF RMR : 20-40.
6. THE ARRANGEMENT OF TOP HEADING MULTI DRIFT AND BENCHING EXCAVATION WILL BE CONFIRMED OR OPTIMIZED BY THE CONTRACTOR ACCORDING TO THEIR AVAILABLE EQUIPMENT AND PREFERRED SOLUTIONS. ACCORDING TO THE DESIGN SOLUTION, ADDITIONAL SUPPORTS SHALL BE INSTALLED ALONG THE TEMPORARY LATERAL SIDEWALLS (I.E. ADDITIONAL SHOTCRETE LAYER WITH ROCK DOWEL A8 AND STEEL RIB ARCH WHERE REQUIRED) TO ENSURE SAFE CONDITIONS DURING.
7. FOR SPECIFIC NOTES REFER TO DRAWING RUFIJI-SHC-ULU-CLH060-00-6/8.
8. THE CHOICE OF THE SUPPORT SECTION TYPE OF DESIGN TO BE APPLIED IS BASED ON GEOMECHANICAL CONDITIONS AT TUNNEL FACE DEFINED BY FACE MAPPING. EACH SECTION TYPE HAS A SPECIFIC FIELD OF APPLICATION BASED ON DEFINED GEOMECHANICAL CONDITIONS. THE SUPPORT VARIABILITY INCLUDED IN EACH SUPPORT SECTION TYPE IS MANAGED ON SITE ON THE BASIS OF VISUAL INSPECTION, EXCAVATION BEHAVIOUR AND MONITORING RESULTS BY THE DESIGN REPRESENTATIVE.

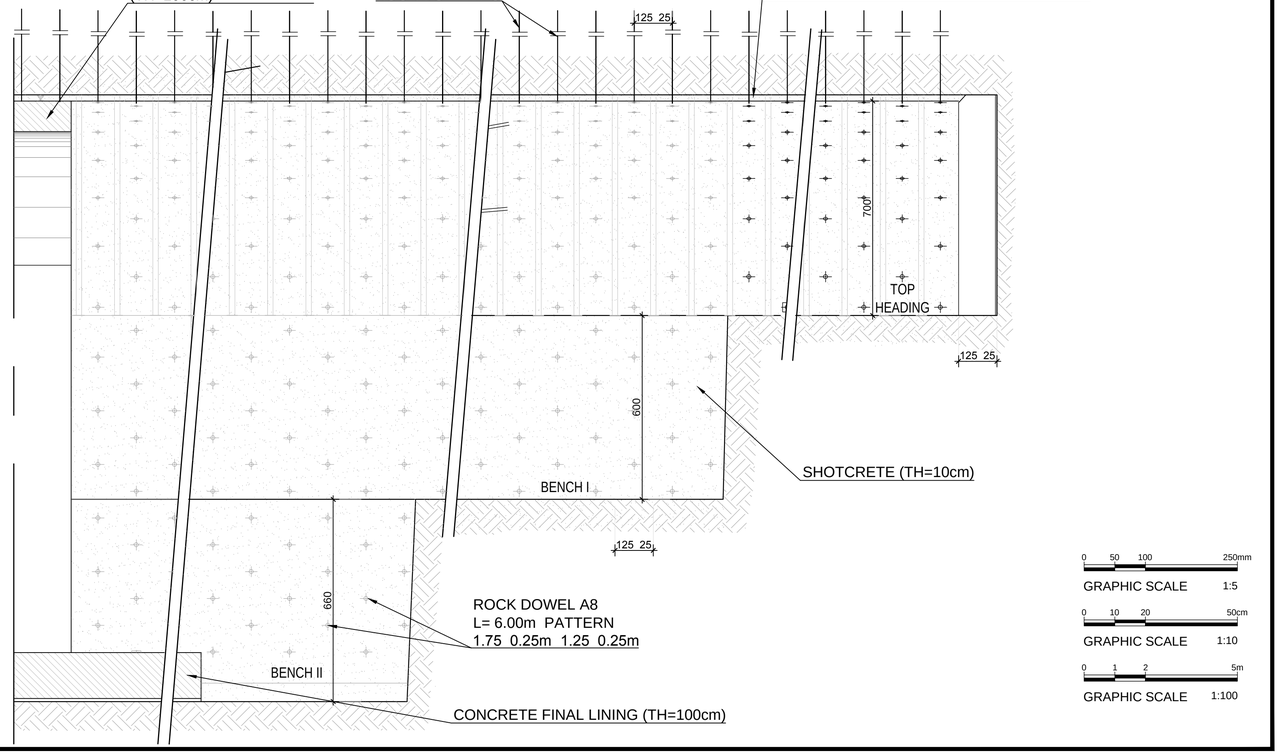
SUPPORT TYPE C2

SCALE 1:100



LONGITUDINAL PROFILE

SCALE 1:100



0 50 100 250mm
GRAPHIC SCALE 1:5

0 10 20 50cm
GRAPHIC SCALE 1:10

0 1 2 5m
GRAPHIC SCALE 1:100

Originator

The Arab Contractors OSMAN AHMAD OSMAN & CO.
المقاولون العرب شركة عثمان أحمد عثمان وشركاه
ELSEWEDY ELECTRIC

Title

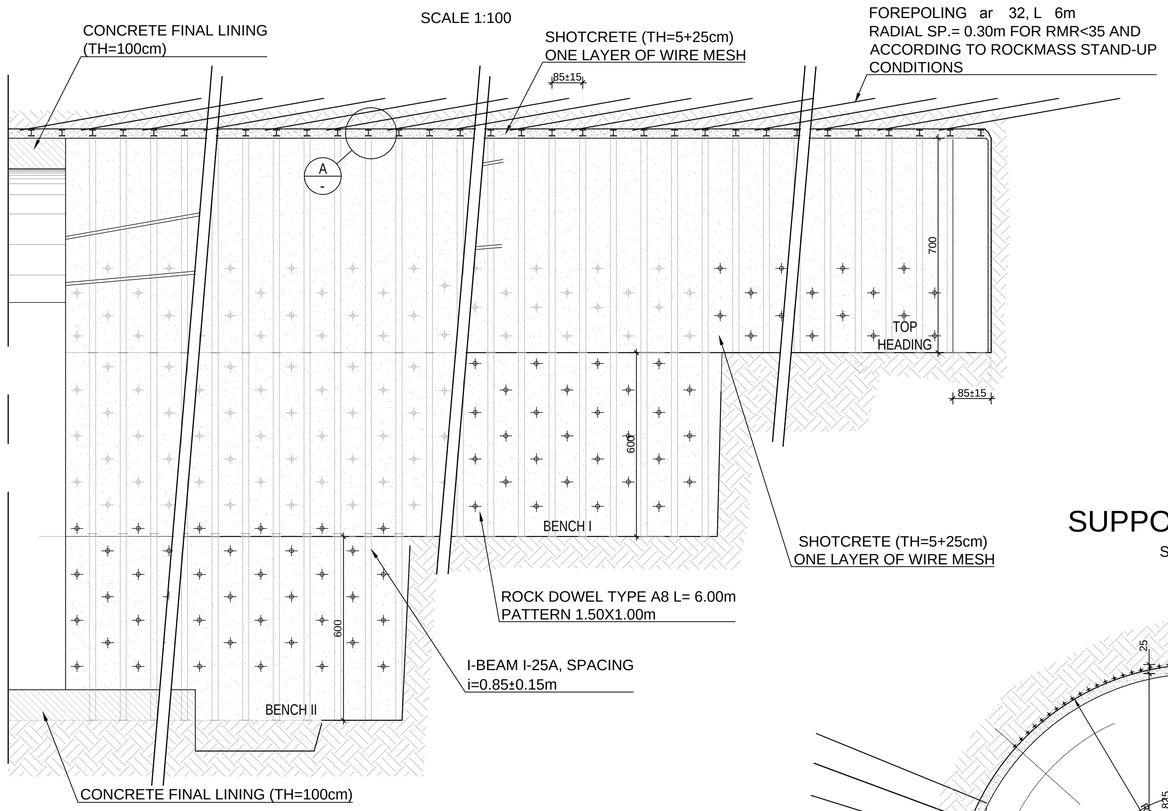
DIVERSION TUNNEL
Primary Support
Upstream Cross Section (Type B) - Support type C2

Detail Design

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Document no. RUF-SHC330-ULX-&CTA010-001003	Rev. 00	PAGE NO. 05

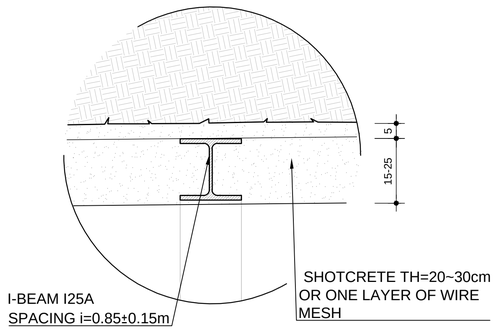
LONGITUDINAL PROFILE

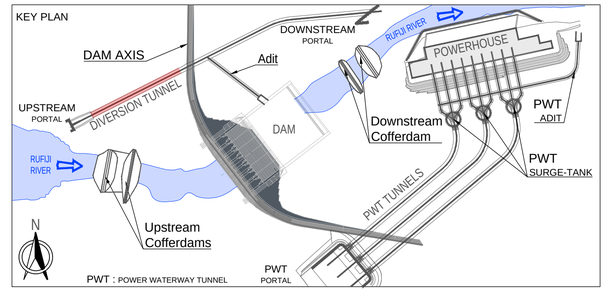
SCALE 1:100



DETAIL "A"

SCALE 1:10



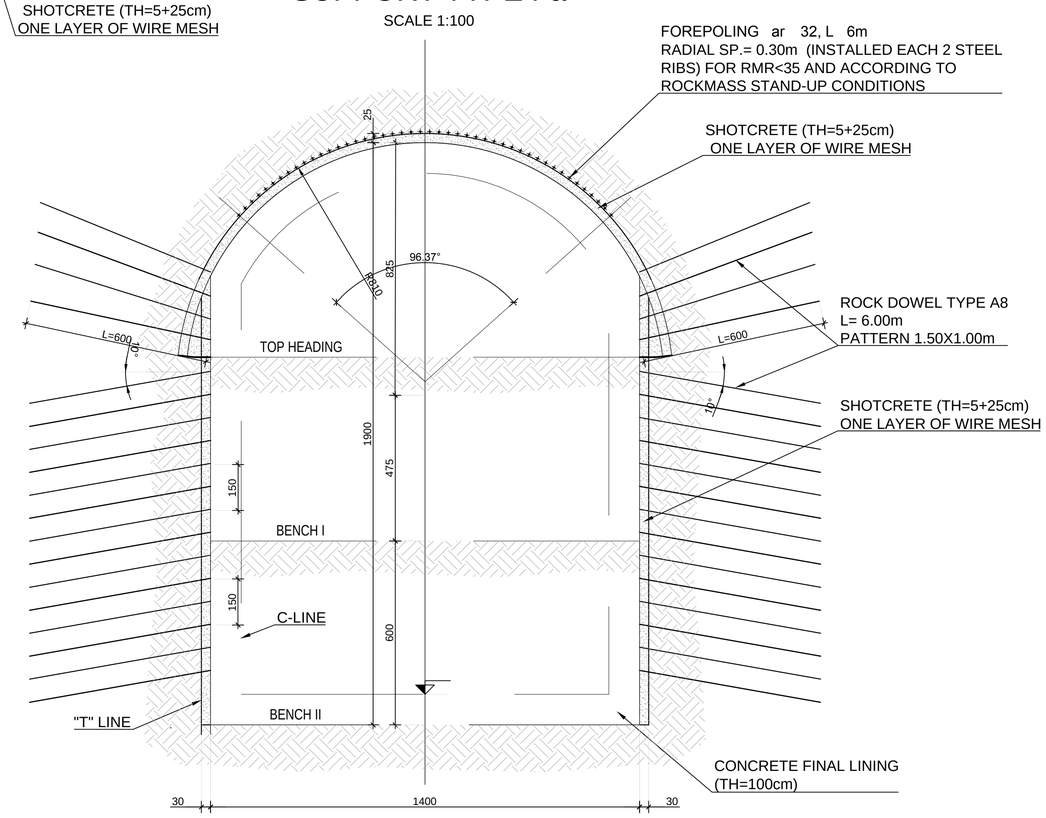


GENERAL NOTES:

1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE FINAL LINING SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, ROCK DOWEL AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED.
4. WATER INFLOW EVALUATION DURING CONSTRUCTION WILL ALLOW TO CONFIRM THE PRESENCE OF DRAINAGE SYSTEM AND/OR TO OPTIMIZE THE NUMBER, LENGTH OF DRAINS AND OVERLAPP. WATER FROM ROCK MASS COLLECTED BY DRAINS MUST BE CHANNELIZED IN DRAINAGE TRENCHES.
5. SUPPORT MEASURES ARE DESIGNED ACCORDING TO AVAILABLE GEOLOGICAL DATA, TO BE VERIFIED ON SITE DURING CONSTRUCTION.
6. TO ENSURE SAFETY FIRST MIN 30mm OF SHOTCRETE SHALL BE INSTALLED ON ALL EXPOSED SURFACE IMMEDIATELY AFTER EXCAVATION.
7. TYPICAL APPLICATION RANGE OF RMR : 15<RMR<20 (Fa) AND RMR<15 (Fb).
8. THE ARRANGEMENT OF TOP HEADING MULTI DRIFT AND BENCHING EXCAVATION WILL BE CONFIRMED OR OPTIMIZED BY THE CONTRACTOR ACCORDING TO THEIR AVAILABLE EQUIPMENT AND PREFERRED SOLUTIONS. ACCORDING TO THE DESIGN SOLUTION, ADDITIONAL SUPPORTS SHALL BE INSTALLED ALONG THE TEMPORARY LATERAL SIDEWALLS (I.E. ADDITIONAL SHOTCRETE LAYER WITH ROCK DOWEL AND STEEL RIB ARCH WHERE REQUIRED) TO ENSURE SAFE CONDITIONS DURING.
9. FACE NAILING DISTRIBUITED SCATTERED AT EACH ADVANCE.
10. THE CHOICE OF THE SUPPORT SECTION TYPE OF DESIGN TO BE APPLIED IS BASED ON GEOMECHANICAL CONDITIONS AT TUNNEL FACE DEFINED BY FACE MAPPING. EACH SECTION TYPE HAS A SPECIFIC FIELD OF APPLICATION BASED ON DEFINED GEOMECHANICAL CONDITIONS. THE SUPPORT VARIABILITY INCLUDED IN EACH SUPPORT SECTION TYPE IS MANAGED ON SITE ON THE BASIS OF VISUAL INSPECTION, EXCAVATION BEHAVIOUR AND MONITORING RESULTS BY THE DESIGN REPRESENTATIVE.

SUPPORT TYPE Fa

SCALE 1:100

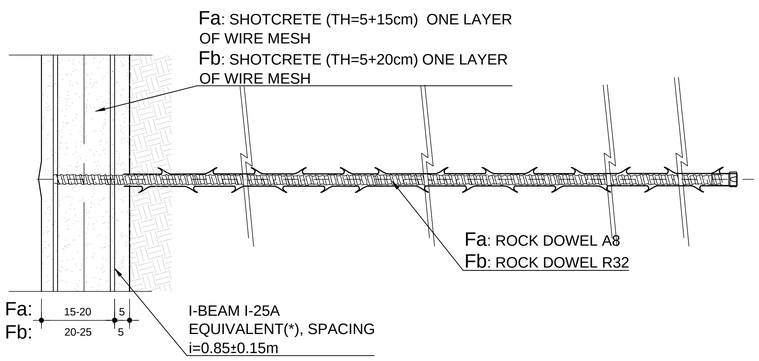


GRAPHIC SCALE 1:100 (0, 1, 2, 5m)

GRAPHIC SCALE 1:10 (0, 10, 20, 50cm)

DETAIL "B"

SCALE 1:10



Originator

The Arab Contractors OSMAN AHMAD OSMAN & CO.

ELSEWEDY ELECTRIC

Title

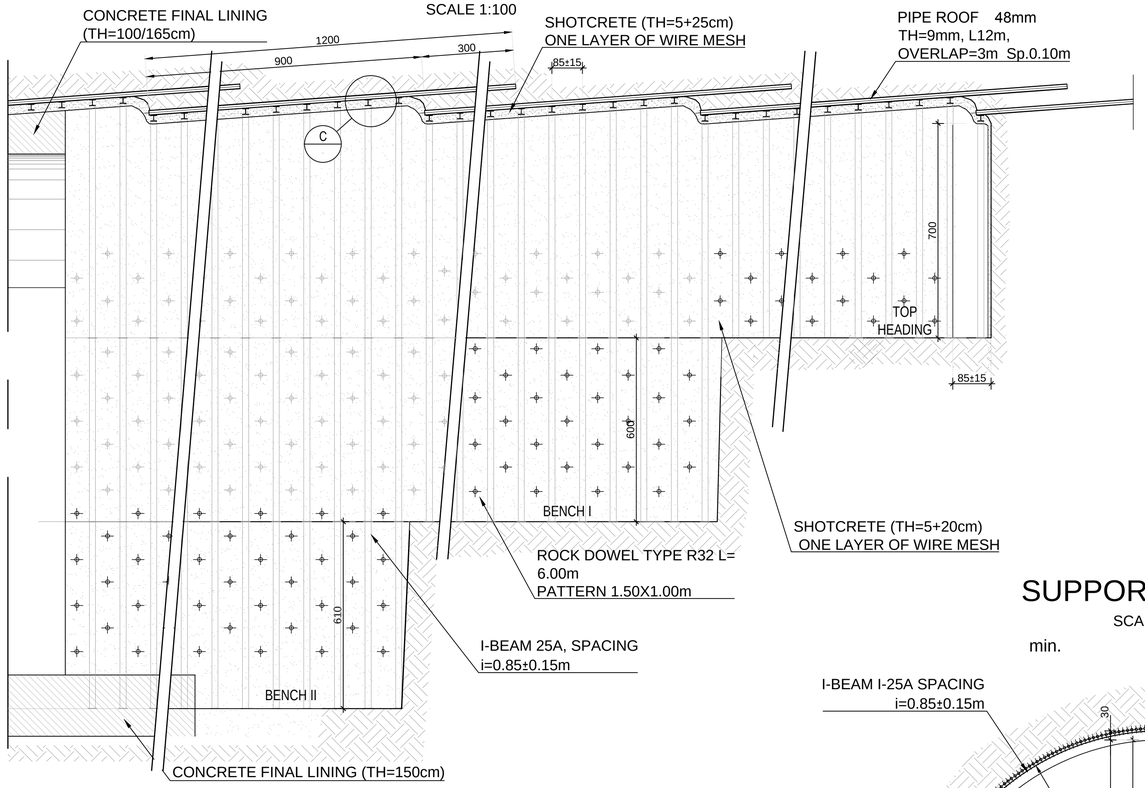
DIVERSION TUNNEL - Primary Support
Upstream Cross Section (Type B)
Support type Fa

Detail Design

Type: BLACK	Scale: As Shown	Size: A3
Document no. RUF-SHC330-ULX-&CTA010-001003	Rev. 00	PAGE NO. 06

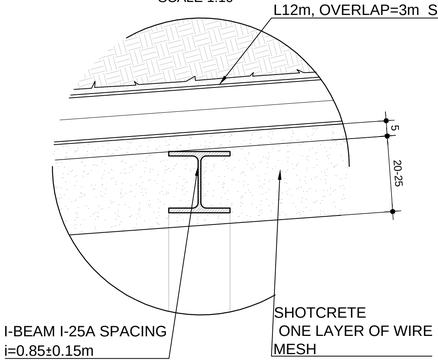
LONGITUDINAL PROFILE

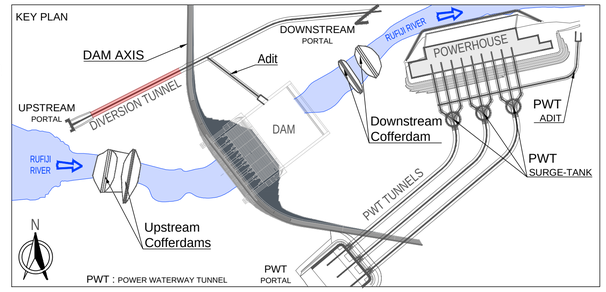
SCALE 1:100



DETAIL "C"

SCALE 1:10



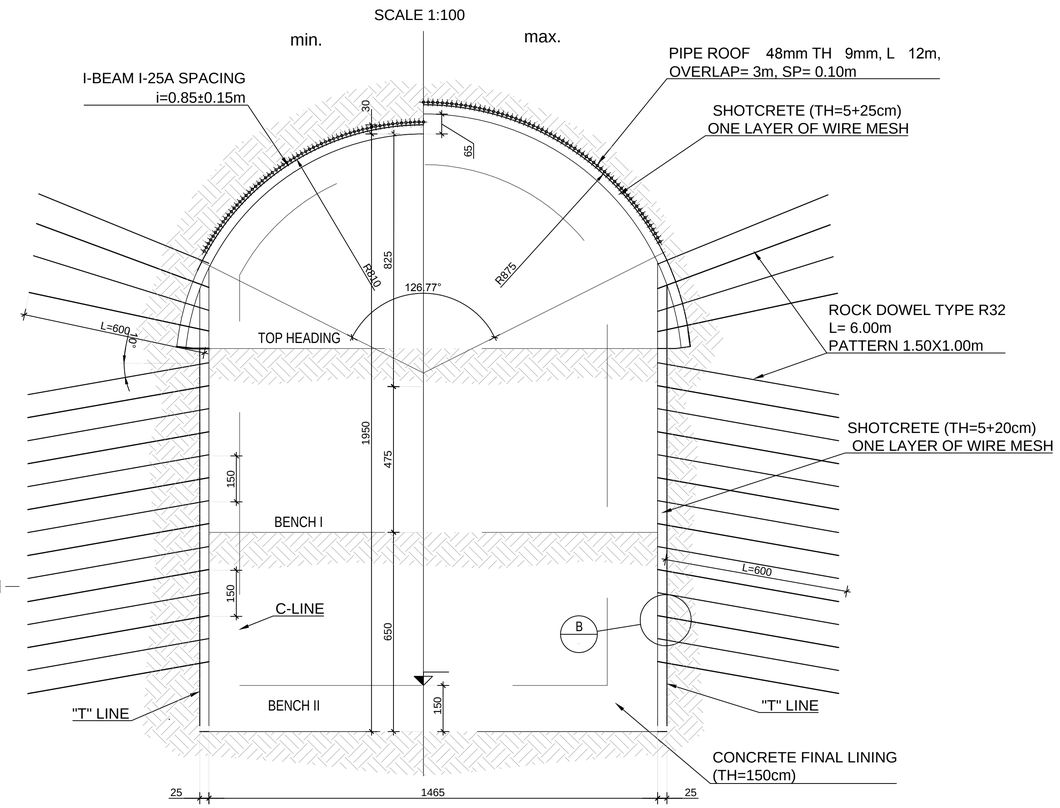


GENERAL NOTES:

1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE FINAL LINING SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, ROCK DOWEL AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED.
4. WATER INFLOW EVALUATION DURING CONSTRUCTION WILL ALLOW TO CONFIRM THE PRESENCE OF DRAINAGE SYSTEM AND/OR TO OPTIMIZE THE NUMBER, LENGTH OF DRAINS AND OVERLAPP. WATER FROM ROCK MASS COLLECTED BY DRAINS MUST BE CHANNELIZED IN DRAINAGE TRENCHES.
5. SUPPORT MEASURES ARE DESIGNED ACCORDING TO AVAILABLE GEOLOGICAL DATA, TO BE VERIFIED ON SITE DURING CONSTRUCTION.
6. TO ENSURE SAFETY FIRST MIN 30mm OF SHOTCRETE SHALL BE INSTALLED ON ALL EXPOSED SURFACE IMMEDIATELY AFTER EXCAVATION.
7. TYPICAL APPLICATION RANGE OF RMR : 15<RMR<20 (Fa) AND RMR<15 (Fb).
8. THE ARRANGEMENT OF TOP HEADING MULTI DRIFT AND BENCHING EXCAVATION WILL BE CONFIRMED OR OPTIMIZED BY THE CONTRACTOR ACCORDING TO THEIR AVAILABLE EQUIPMENT AND PREFERRED SOLUTIONS. ACCORDING TO THE DESIGN SOLUTION, ADDITIONAL SUPPORTS SHALL BE INSTALLED ALONG THE TEMPORARY LATERAL SIDEWALLS (I.E. ADDITIONAL SHOTCRETE LAYER WITH ROCK DOWEL AND STEEL RIB ARCH WHERE REQUIRED) TO ENSURE SAFE CONDITIONS DURING.
9. THE CHOICE OF THE SUPPORT SECTION TYPE OF DESIGN TO BE APPLIED IS BASED ON GEOMECHANICAL CONDITIONS AT TUNNEL FACE DEFINED BY FACE MAPPING. EACH SECTION TYPE HAS A SPECIFIC FIELD OF APPLICATION BASED ON DEFINED GEOMECHANICAL CONDITIONS. THE SUPPORT VARIABILITY INCLUDED IN EACH SUPPORT SECTION TYPE IS MANAGED ON SITE ON THE BASIS OF VISUAL INSPECTION, EXCAVATION BEHAVIOUR AND MONITORING RESULTS BY THE DESIGN REPRESENTATIVE.

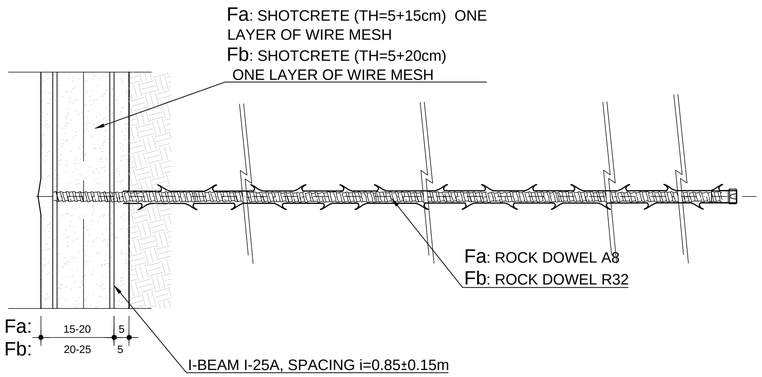
SUPPORT TYPE Fb

SCALE 1:100



DETAIL "B"

SCALE 1:10



0 1 2 5m
GRAPHIC SCALE 1:100

0 10 20 50cm
GRAPHIC SCALE 1:10

( ) IN TERMS OF AREA (Amin 65.3cm) AND MOMENT OF INERTIA (J ,min 3831cm^4)

Originator

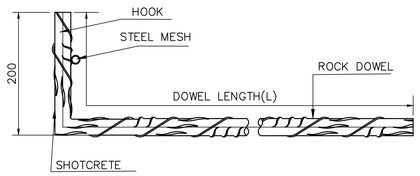
The Arab Contractors OSMAN AHMAD OSMAN & CO.
ELSEWEDY ELECTRIC

Title

DIVERSION TUNNEL - Primary Support
Upstream Cross Section (Type B)
Support type Fb

Detail Design

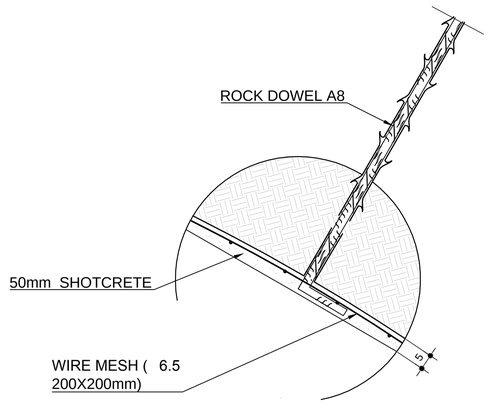
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Document no. RUF-SHC330-ULX-&CTA010-001003	Rev. 00	PAGE NO. 07



ROCK DOWEL

SCALE 1:5
(measured in mm)

EXACAVATION METHOD	PRIMARY SUPPORT TYPE B Range of application: 60≤RMR & 4.64≤Q
TOP-HEADING & BENCHING EXCAVATION	ROUND LENGHT: 2.50-3.50m
	50mm SHOTCRETE WITH SINGLE WIRE MESH (ϕ6.5 200X200mm) IN THE CROWN AND 50mm SHOTCRETE IN THE SIDEWAY
	SYSTEMATIC ROCK DOWEL A8 PATTERN 2.5×2.5m IN THE CROWN AND FEARURE ROCK DOWEL A8 PATTERN 2.5×2.5m IN THE SIDEWALLS, ROCK DOWEL A8 WITH Fy≥200KN (DIA.25mm MIN), L=4.5m

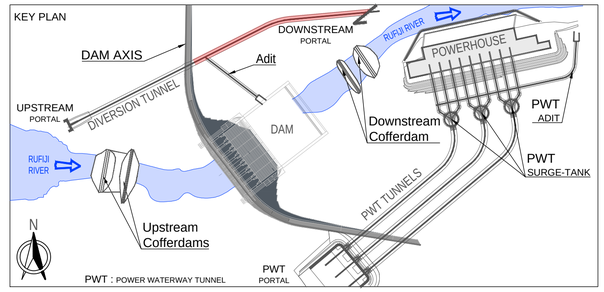


DETAIL "A"

SCALE 1:10

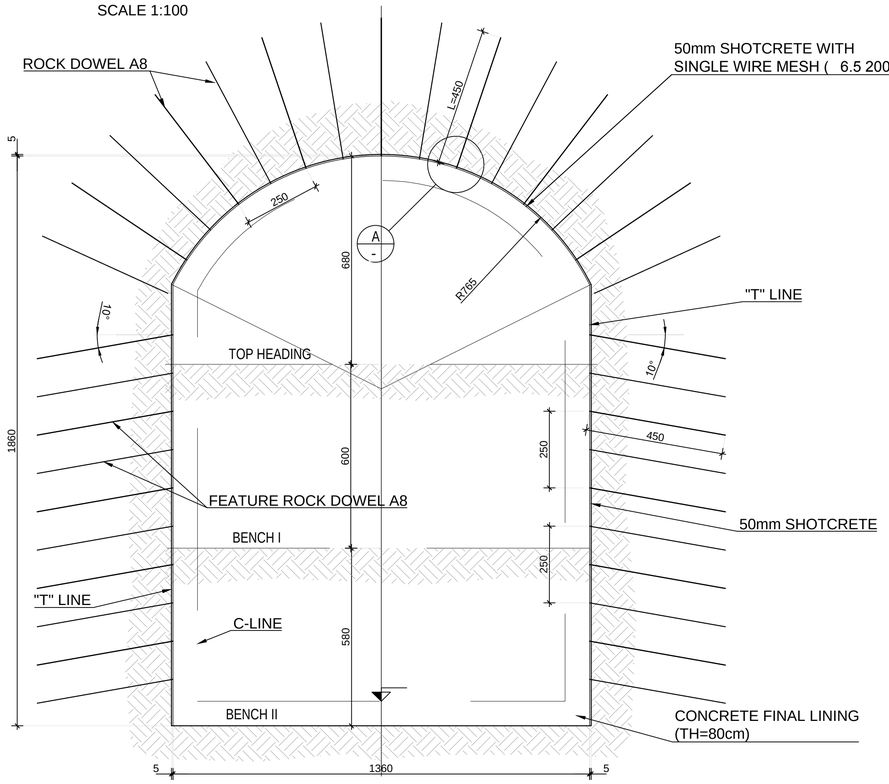
GENERAL NOTES:

1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE FINAL LINING SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, ROCK DOWEL AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED.
4. WATER INFLOW EVALUATION DURING CONSTRUCTION WILL ALLOW TO CONFIRM THE PRESENCE OF DRAINAGE SYSTEM AND/OR TO OPTIMIZE THE NUMBER, LENGTH OF DRAINS AND OVERLAPP. WATER FROM ROCK MASS COLLECTED BY DRAINS MUST BE CHANNELIZED IN DRAINAGE TRENCHES.
5. SUPPORT MEASURES ARE DESIGNED ACCORDING TO AVAILABLE GEOLOGICAL DATA, TO BE VERIFIED ON SITE DURING CONSTRUCTION.
6. TYPICAL APPLICATION RANGE OF RMR : >60.
7. THE ARRANGEMENT OF TOP HEADING MULTI DRIFT AND BENCHING EXCAVATION WILL BE CONFIRMED OR OPTIMIZED BY THE CONTRACTOR ACCORDING TO THEIR AVAILABLE EQUIPMENT AND PREFERRED SOLUTIONS. ACCORDING TO THE DESIGN SOLUTION, ADDITIONAL SUPPORTS SHALL BE INSTALLED ALONG THE TEMPORARY LATERAL SIDEWALLS (I.E. ADDITIONAL SHOTCRETE LAYER WITH ROCK DOWEL AND STEEL RIB ARCH WHERE REQUIRED) TO ENSURE SAFE CONDITIONS DURING.
8. FOR SPECIFIC NOTES REFER TO DRAWING RUFIJI-SHC-ULU-CLH060-00-6/8
9. THE CHOICE OF THE SUPPORT SECTION TYPE OF DESIGN TO BE APPLIED IS BASED ON GEOMECHANICAL CONDITIONS AT TUNNEL FACE DEFINED BY FACE MAPPING. EACH SECTION TYPE HAS A SPECIFIC FIELD OF APPLICATION BASED ON DEFINED GEOMECHANICAL CONDITIONS. THE SUPPORT VARIABILITY INCLUDED IN EACH SUPPORT SECTION TYPE IS MANAGED ON SITE ON THE BASIS OF VISUAL INSPECTION, EXCAVATION BEHAVIOUR AND MONITORING RESULTS BY THE DESIGN REPRESENTATIVE.



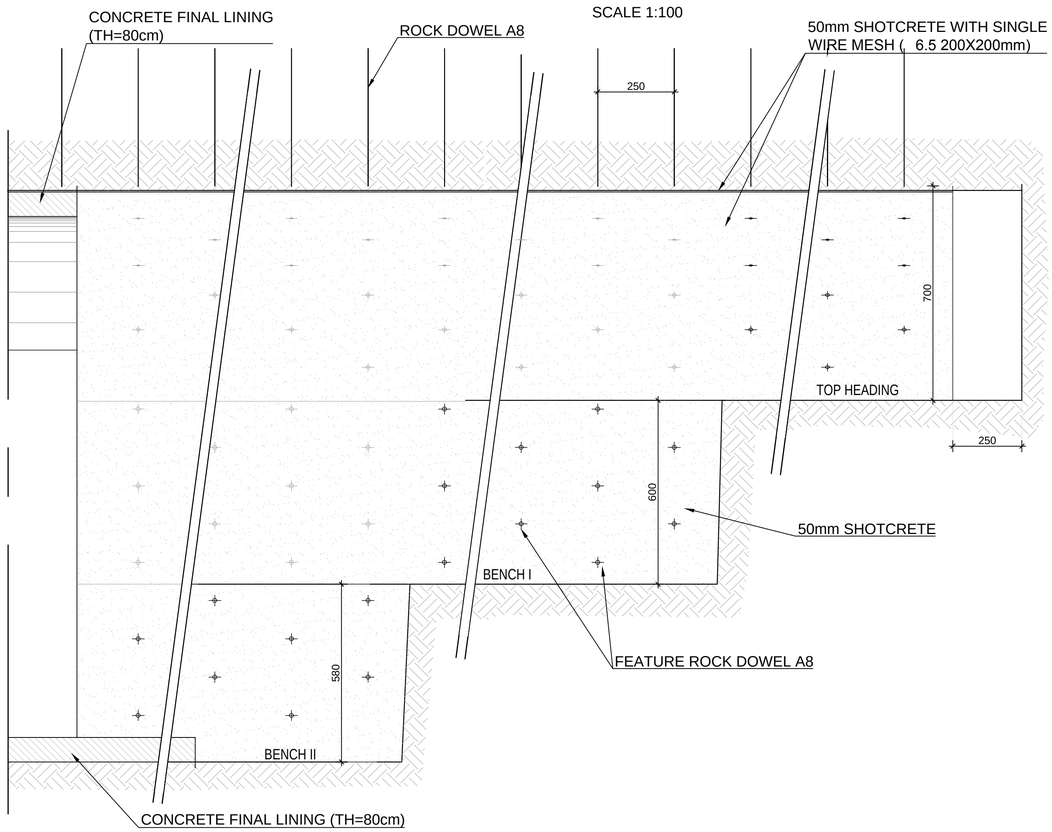
SUPPORT TYPE B

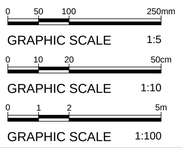
SCALE 1:100



LONGITUDINAL PROFILE

SCALE 1:100





Originator

The Arab Contractors OSMAN AHMAD OSMAN & CO.
المقاولون العرب
عثمان أحمد عثمان وشركاه
ELSEWEDY ELECTRIC

Title

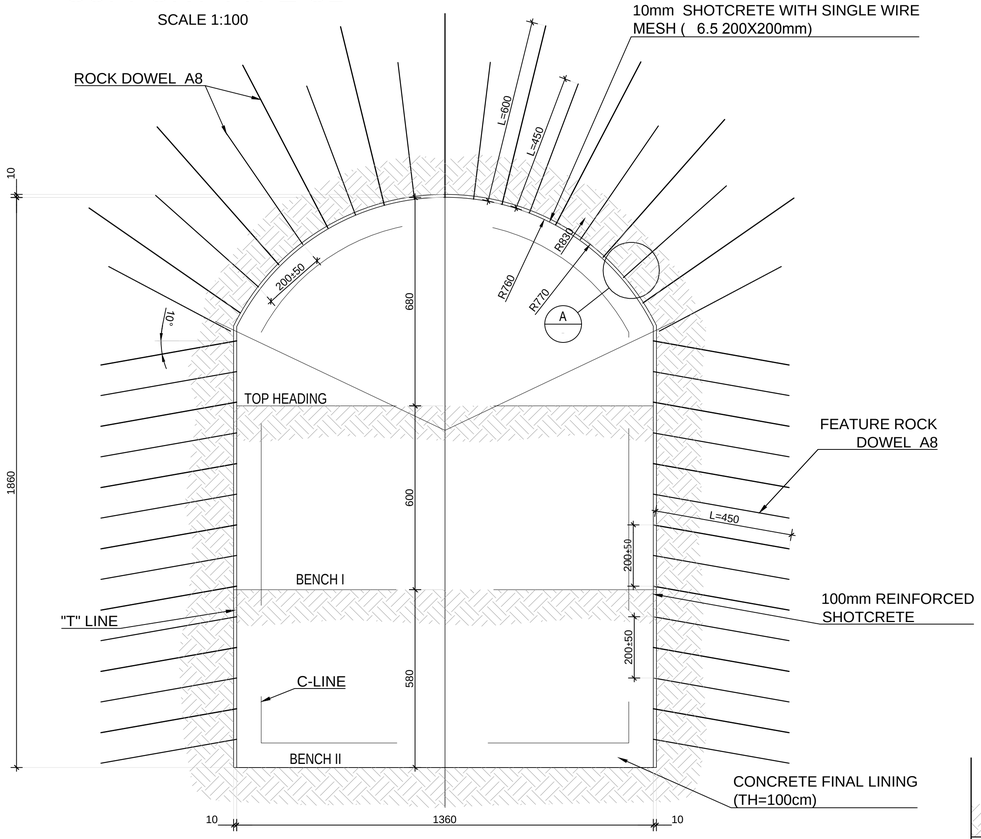
DIVERSION TUNNEL
Primary Support
Downstream Cross Section (Type C) Support type B

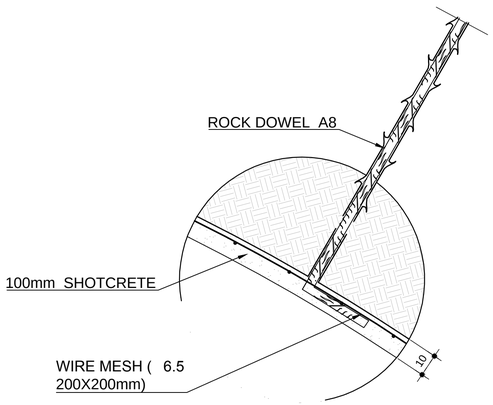
Detail Design

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Document no. RUF-SHC330-ULX-&CTA010-001003	Rev. 00	PAGE NO. 08

SUPPORT TYPE C1

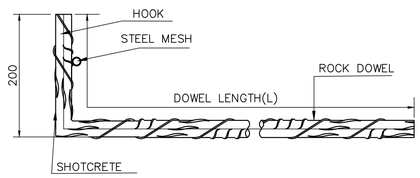
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DETAIL "A"

SCALE 1:10

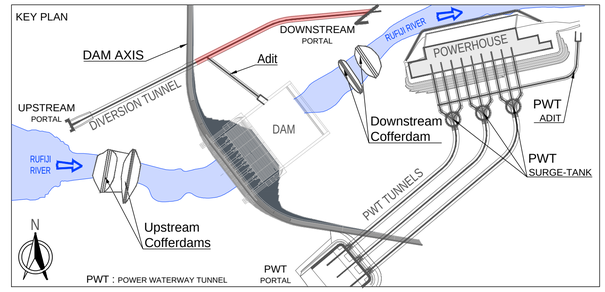


ROCK DOWEL

SCALE 1:5
(measured in mm)

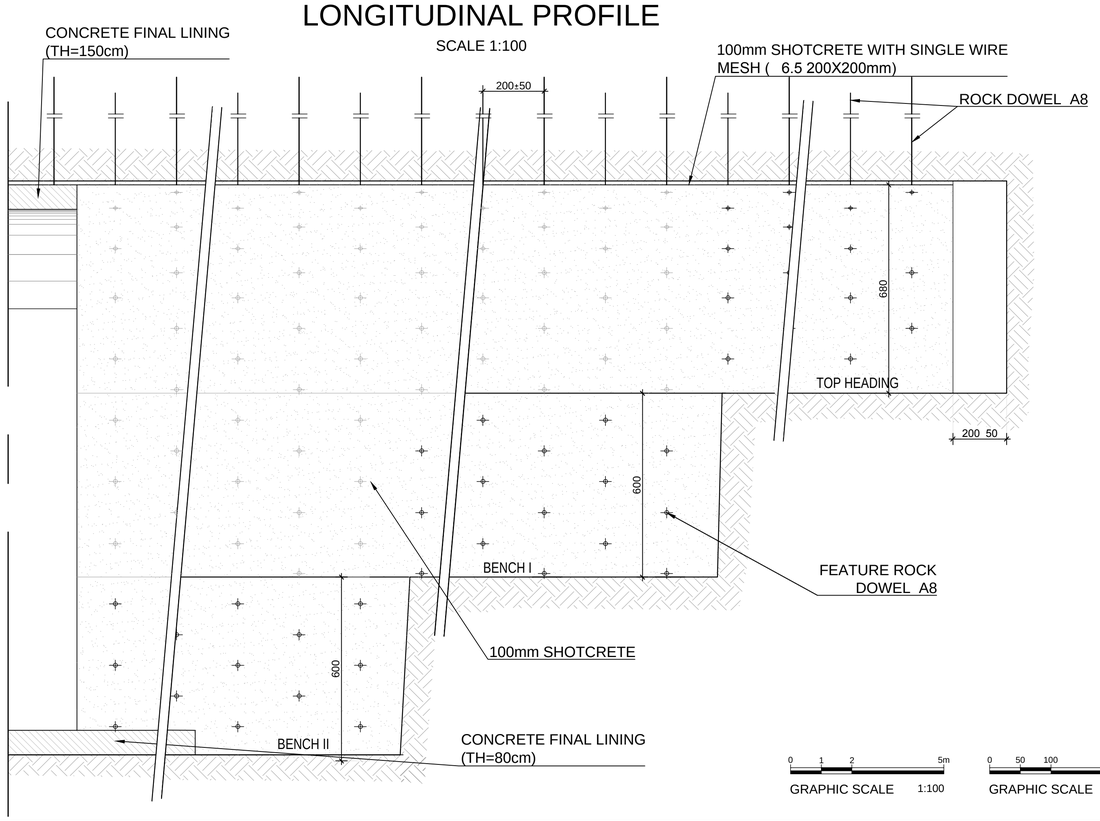
GENERAL NOTES:

1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE FINAL LINING SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, ROCK DOWELS AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED.
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5. SUPPORT MEASURES ARE DESIGNED ACCORDING TO AVAILABLE GEOLOGICAL DATA, TO BE VERIFIED ON SITE DURING CONSTRUCTION.
6. TO ENSURE SAFETY FIRST MIN 30mm OF SHOTCRETE SHALL BE INSTALLED ON ALL EXPOSED SURFACE IMMEDIATELY AFTER EXCAVATION.
7. TYPICAL APPLICATION RANGE OF RMR : 40-60.
8. THE ARRANGEMENT OF TOP HEADING MULTI DRIFT AND BENCHING EXCAVATION WILL BE CONFIRMED OR OPTIMIZED BY THE CONTRACTOR ACCORDING TO THEIR AVAILABLE EQUIPMENT AND PREFERRED SOLUTIONS. ACCORDING TO THE DESIGN SOLUTION, ADDITIONAL SUPPORTS SHALL BE INSTALLED ALONG THE TEMPORARY LATERAL SIDEWALLS (I.E. ADDITIONAL SHOTCRETE LAYER WITH ROCK DOWEL AND STEEL RIB ARCH WHERE REQUIRED) TO ENSURE SAFE CONDITIONS DURING.
9. THE CHOICE OF THE SUPPORT SECTION TYPE OF DESIGN TO BE APPLIED IS BASED ON GEOMECHANICAL CONDITIONS AT TUNNEL FACE DEFINED BY FACE MAPPING. EACH SECTION TYPE HAS A SPECIFIC FIELD OF APPLICATION BASED ON DEFINED GEOMECHANICAL CONDITIONS. THE SUPPORT VARIABILITY INCLUDED IN EACH SUPPORT SECTION TYPE IS MANAGED ON SITE ON THE BASIS OF VISUAL INSPECTION, EXCAVATION BEHAVIOUR AND MONITORING RESULTS BY THE DESIGN REPRESENTATIVE.



LONGITUDINAL PROFILE

SCALE 1:100



GRAPHIC SCALE 1:100 (0 1 2 5m)

GRAPHIC SCALE 1:5 (0 50 100 250mm)

GRAPHIC SCALE 1:10 (0 10 20 50cm)

Originator

TheArabContractors OSMAN AHMAD OSMAN & CO. المقاولون العرب عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

DIVERSION TUNNEL - Primary Support

Detail Design

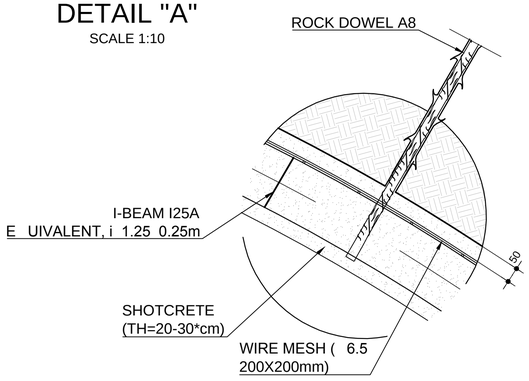
Downstream Cross Section (Type C) Support type C1

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Document no.	Rev.	PAGE NO.
RUF-SHC330-ULX-&CTA010-001003	Rev. 00	09

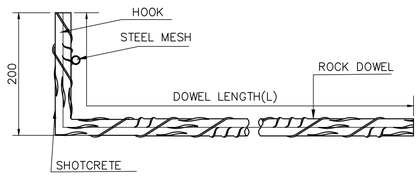
DETAIL "A"

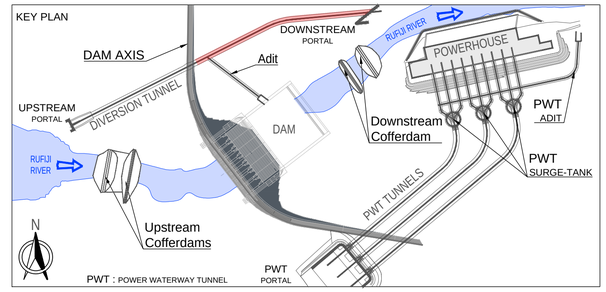
SCALE 1:10



ROCK DOWEL A8

SCALE 1:5
(measured in mm)





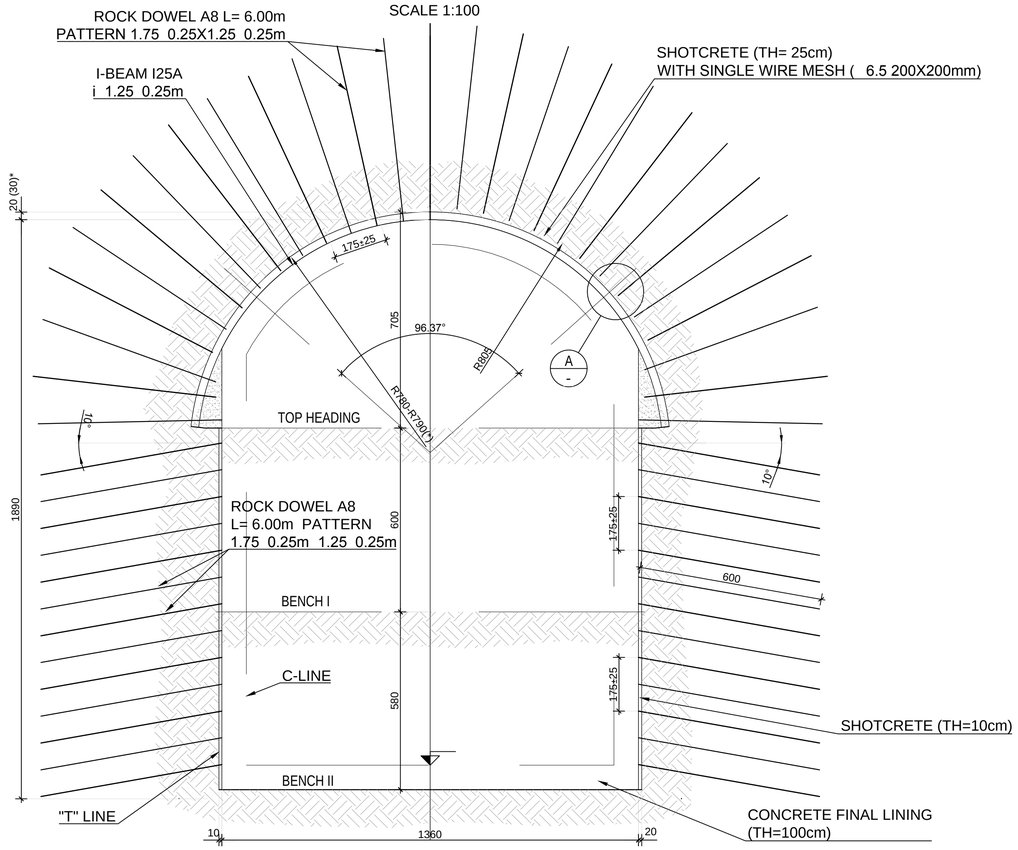
GENERAL NOTES:

1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
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5. SUPPORT MEASURES ARE DESIGNED ACCORDING TO AVAILABLE GEOLOGICAL DATA, TO BE VERIFIED ON SITE DURING CONSTRUCTION.
6. SHOTCRETE THICKNESS MUST BE INCREASED LOCALLY TO ENSURE MIN 30mm LATTICE GIRDER COVER FOR PROTECTION AGAINST CORROSION.
7. TO ENSURE SAFETY FIRST MIN 30mm OF SHOTCRETE SHALL BE INSTALLED ON ALL EXPOSED SURFACE IMMEDIATELY AFTER EXCAVATION.
8. TYPICAL APPLICATION RANGE OF RMR : 20-40.
9. THE ARRANGEMENT OF TOP HEADING MULTI DRIFT AND BENCHING EXCAVATION WILL BE CONFIRMED OR OPTIMIZED BY THE CONTRACTOR ACCORDING TO THEIR AVAILABLE EQUIPMENT AND PREFERRED SOLUTIONS. ACCORDING TO THE DESIGN SOLUTION, ADDITIONAL SUPPORTS SHALL BE INSTALLED ALONG THE TEMPORARY LATERAL SIDEWALLS (I.E. ADDITIONAL SHOTCRETE LAYER WITH ROCK DOWEL A8 AND STEEL RIB ARCH WHERE REQUIRED) TO ENSURE SAFE CONDITIONS DURING.

1.
2. FOR SPECIFIC NOTES REFER TO DRAWING RUFIJI-SHC-ULU-CLH060-00-6/8.
3. THE CHOICE OF THE SUPPORT SECTION TYPE OF DESIGN TO BE APPLIED IS BASED ON GEOMECHANICAL CONDITIONS AT TUNNEL FACE DEFINED BY FACE MAPPING. EACH SECTION TYPE HAS A SPECIFIC FIELD OF APPLICATION BASED ON DEFINED GEOMECHANICAL CONDITIONS. THE SUPPORT VARIABILITY INCLUDED IN EACH SUPPORT SECTION TYPE IS MANAGED ON SITE ON THE BASIS OF VISUAL INSPECTION, EXCAVATION BEHAVIOUR AND MONITORING RESULTS BY THE DESIGN REPRESENTATIVE.

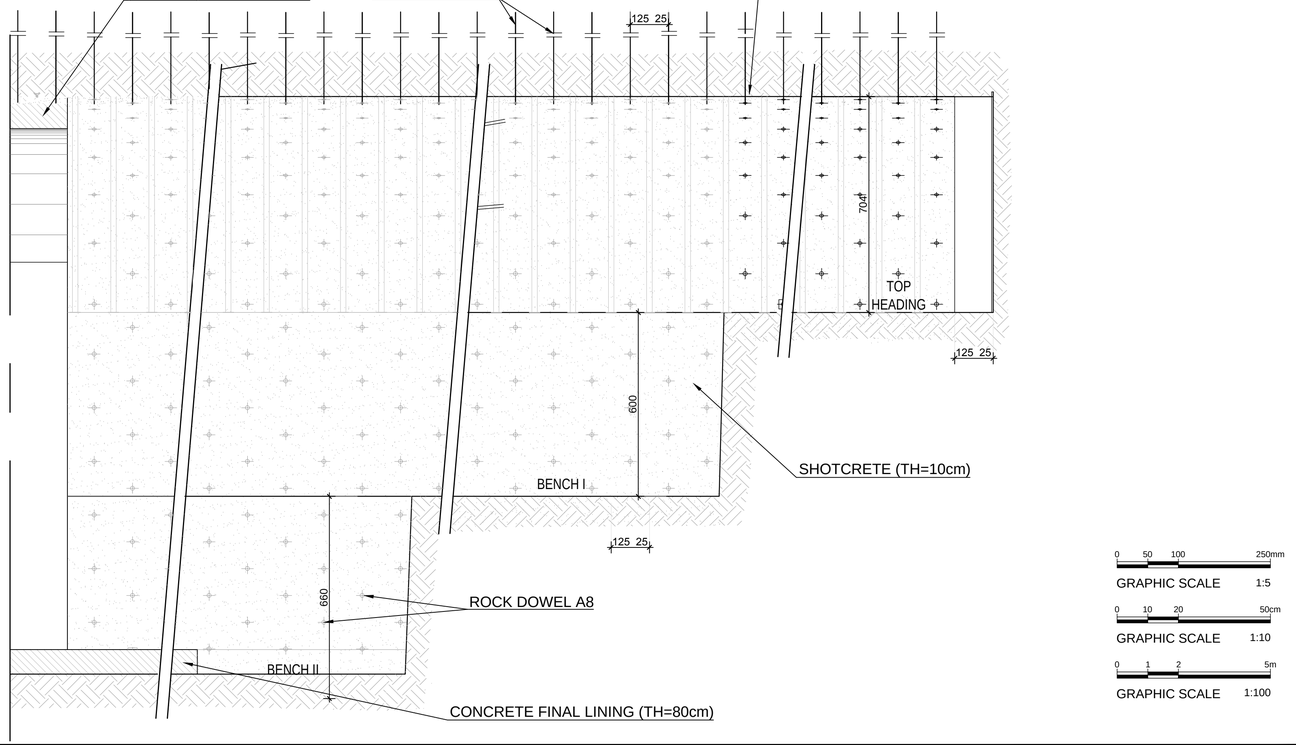
SUPPORT TYPE C2

SCALE 1:100



LONGITUDINAL PROFILE

SCALE 1:100



0 50 100 250mm
GRAPHIC SCALE 1:5

0 10 20 50cm
GRAPHIC SCALE 1:10

0 1 2 5m
GRAPHIC SCALE 1:100

Originator

The Arab Contractors
OSMAN AHMAD OSMAN & CO.
المقاولون العرب
عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

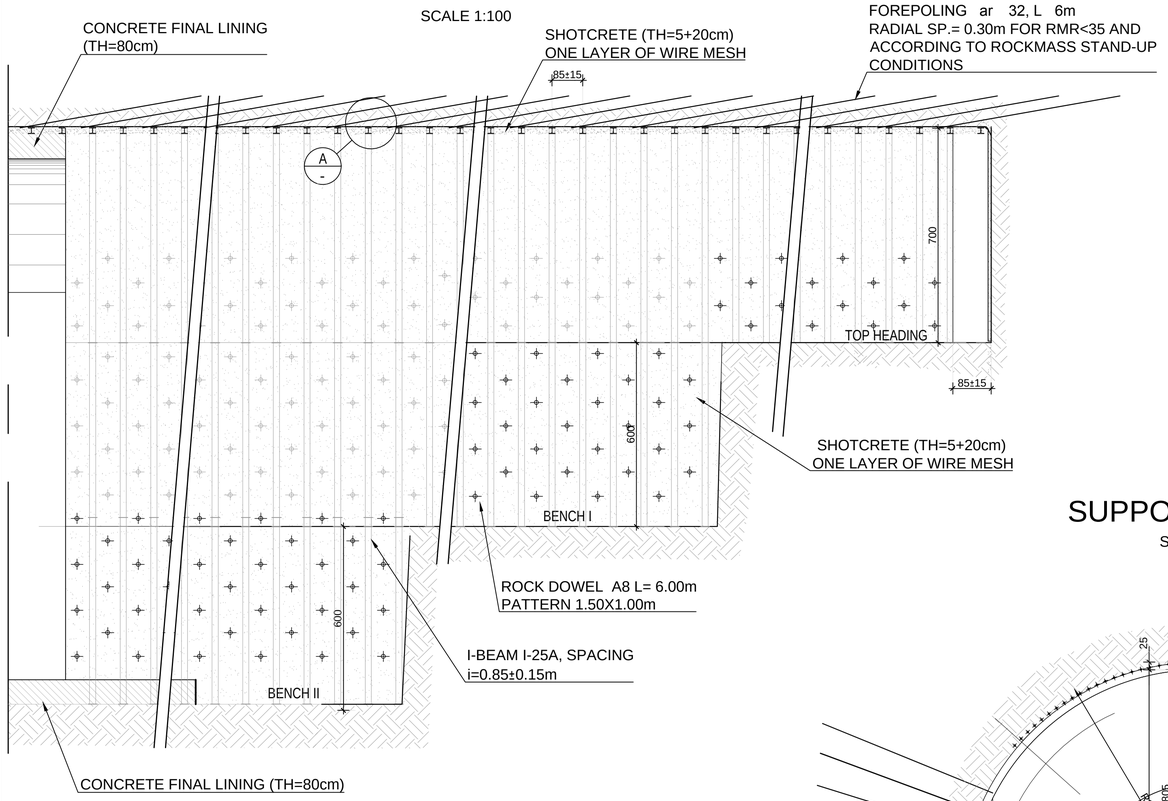
DIVERSION TUNNEL
Primary Support
Dpstream Cross Section (Type C) - Support type C2

Detail Design

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Document no. RUF-SHC330-ULX-&CTA010-001003	Rev. 00	PAGE NO. 10

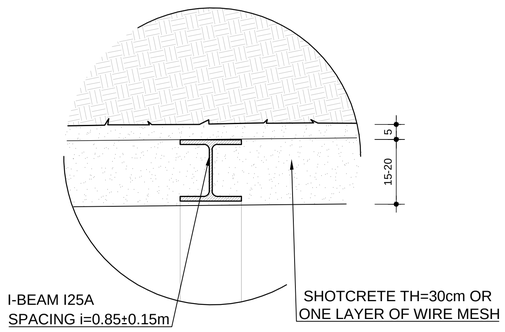
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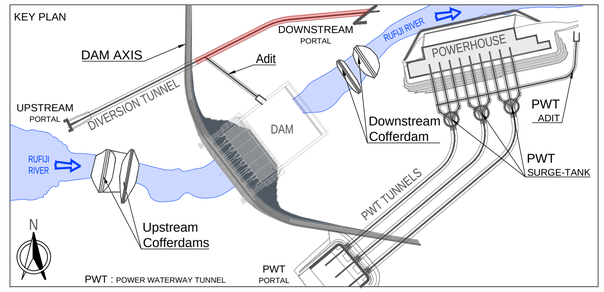
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DETAIL "A"

SCALE 1:10



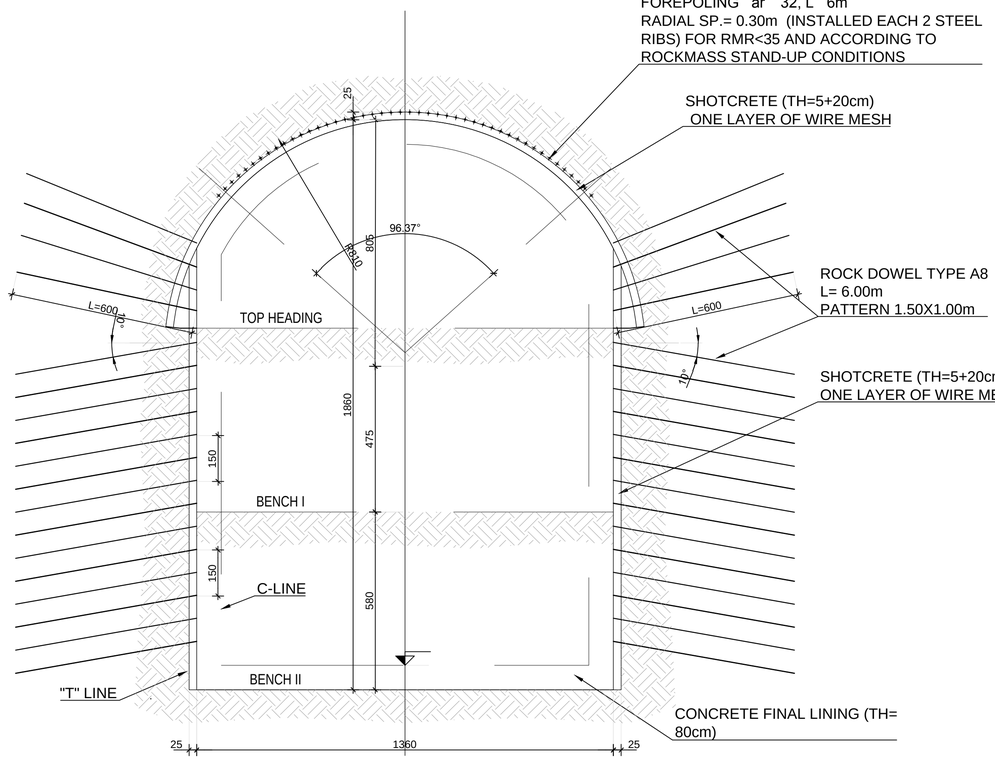


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4. WATER INFLOW EVALUATION DURING CONSTRUCTION WILL ALLOW TO CONFIRM THE PRESENCE OF DRAINAGE SYSTEM AND/OR TO OPTIMIZE THE NUMBER, LENGTH OF DRAINS AND OVERLAPP. WATER FROM ROCK MASS COLLECTED BY DRAINS MUST BE CHANNELIZED IN DRAINAGE TRENCHES.
5. SUPPORT MEASURES ARE DESIGNED ACCORDING TO AVAILABLE GEOLOGICAL DATA, TO BE VERIFIED ON SITE DURING CONSTRUCTION.
6. TO ENSURE SAFETY FIRST MIN 30mm OF SHOTCRETE SHALL BE INSTALLED ON ALL EXPOSED SURFACE IMMEDIATELY AFTER EXCAVATION.
7. TYPICAL APPLICATION RANGE OF RMR : 15<RMR<20 (Fa) AND RMR<15 (Fb).
8. THE ARRANGEMENT OF TOP HEADING MULTI DRIFT AND BENCHING EXCAVATION WILL BE CONFIRMED OR OPTIMIZED BY THE CONTRACTOR ACCORDING TO THEIR AVAILABLE EQUIPMENT AND PREFERRED SOLUTIONS. ACCORDING TO THE DESIGN SOLUTION, ADDITIONAL SUPPORTS SHALL BE INSTALLED ALONG THE TEMPORARY LATERAL SIDEWALLS (I.E. ADDITIONAL SHOTCRETE LAYER WITH ROCK DOWEL AND STEEL RIB ARCH WHERE REQUIRED) TO ENSURE SAFE CONDITIONS DURING.
9. FACE NAILING DISTRIBUITED SCATTERED AT EACH ADVANCE.
10. THE CHOICE OF THE SUPPORT SECTION TYPE OF DESIGN TO BE APPLIED IS BASED ON GEOMECHANICAL CONDITIONS AT TUNNEL FACE DEFINED BY FACE MAPPING. EACH SECTION TYPE HAS A SPECIFIC FIELD OF APPLICATION BASED ON DEFINED GEOMECHANICAL CONDITIONS. THE SUPPORT VARIABILITY INCLUDED IN EACH SUPPORT SECTION TYPE IS MANAGED ON SITE ON THE BASIS OF VISUAL INSPECTION, EXCAVATION BEHAVIOUR AND MONITORING RESULTS BY THE DESIGN REPRESENTATIVE.

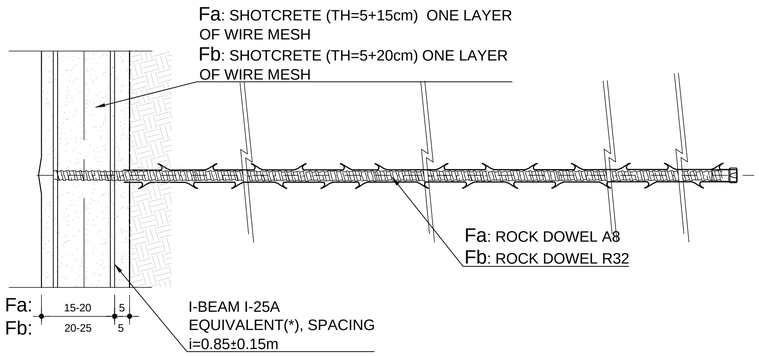
SUPPORT TYPE Fa

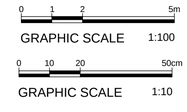
SCALE 1:100



DETAIL "B"

SCALE 1:10





Originator

The Arab Contractors — Osman Ahmad Osman & Co. — المقاولون العرب — شركة عثمان أحمد عثمان وشركاه

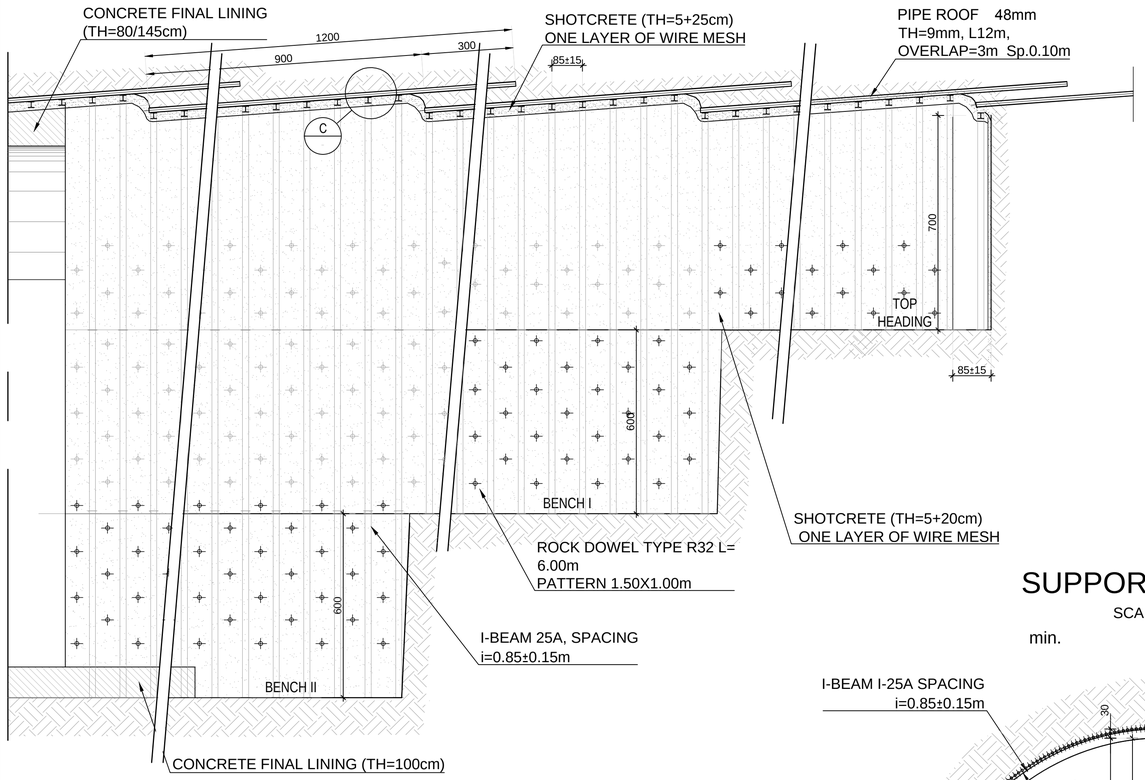
ELSEWEDY ELECTRIC

Title

DIVERSION TUNNEL - Primary Support
Downstream Cross Section (Type C)
Support type Fa

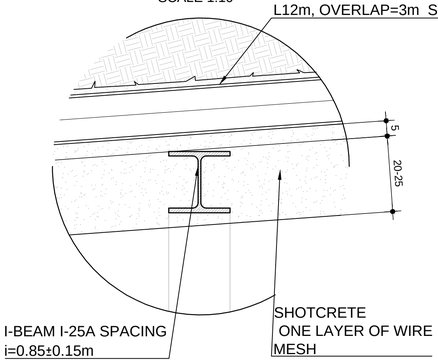
Detail Design

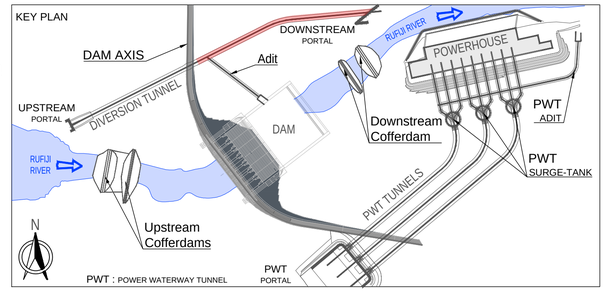
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DETAIL "C"

SCALE 1:10



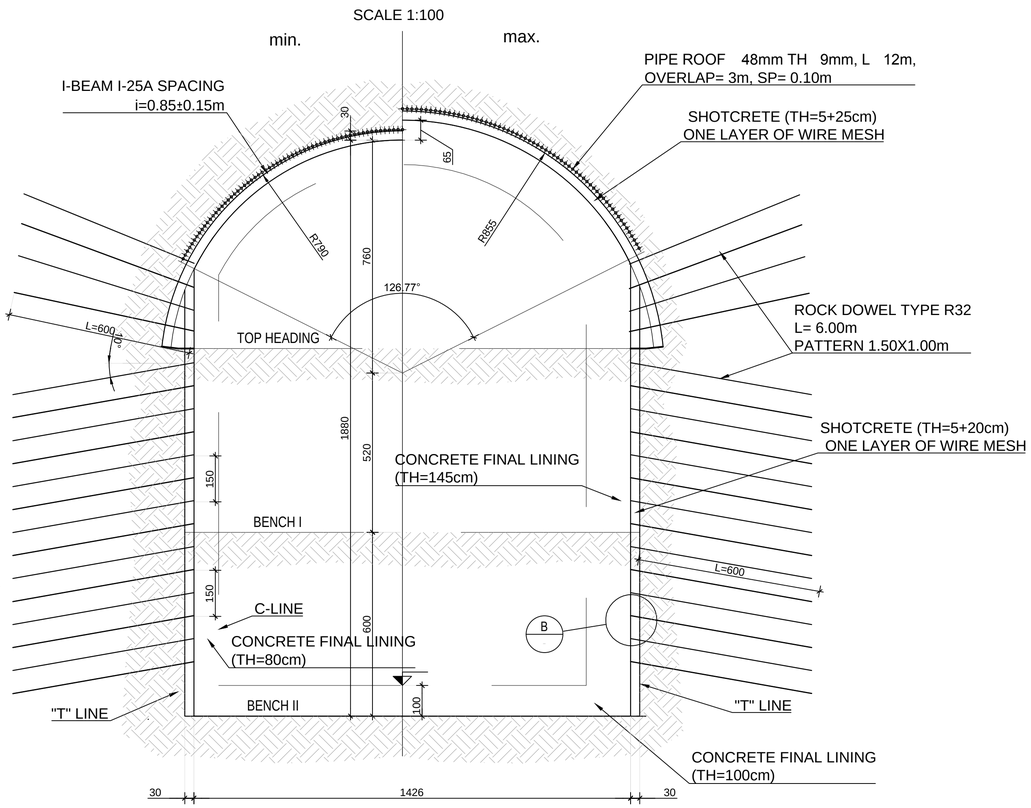


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5. SUPPORT MEASURES ARE DESIGNED ACCORDING TO AVAILABLE GEOLOGICAL DATA, TO BE VERIFIED ON SITE DURING CONSTRUCTION.
6. TO ENSURE SAFETY FIRST MIN 30mm OF SHOTCRETE SHALL BE INSTALLED ON ALL EXPOSED SURFACE IMMEDIATELY AFTER EXCAVATION.
7. TYPICAL APPLICATION RANGE OF RMR : 15<RMR<20 (Fa) AND RMR<15 (Fb).
8. THE ARRANGEMENT OF TOP HEADING MULTI DRIFT AND BENCHING EXCAVATION WILL BE CONFIRMED OR OPTIMIZED BY THE CONTRACTOR ACCORDING TO THEIR AVAILABLE EQUIPMENT AND PREFERRED SOLUTIONS. ACCORDING TO THE DESIGN SOLUTION, ADDITIONAL SUPPORTS SHALL BE INSTALLED ALONG THE TEMPORARY LATERAL SIDEWALLS (I.E. ADDITIONAL SHOTCRETE LAYER WITH ROCK DOWEL AND STEEL RIB ARCH WHERE REQUIRED) TO ENSURE SAFE CONDITIONS DURING.
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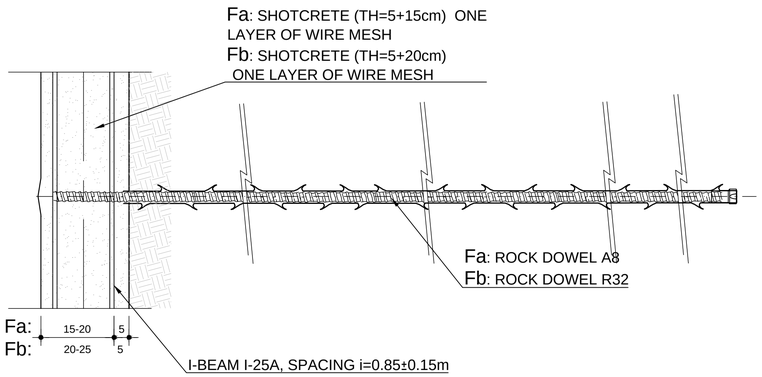
SUPPORT TYPE Fb

SCALE 1:100



DETAIL "B"

SCALE 1:10



0 1 2 5m
GRAPHIC SCALE 1:100

0 10 20 50cm
GRAPHIC SCALE 1:10

Originator

The Arab Contractors
OSMAN AHMAD OSMAN & CO.
المقاولون العرب
عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

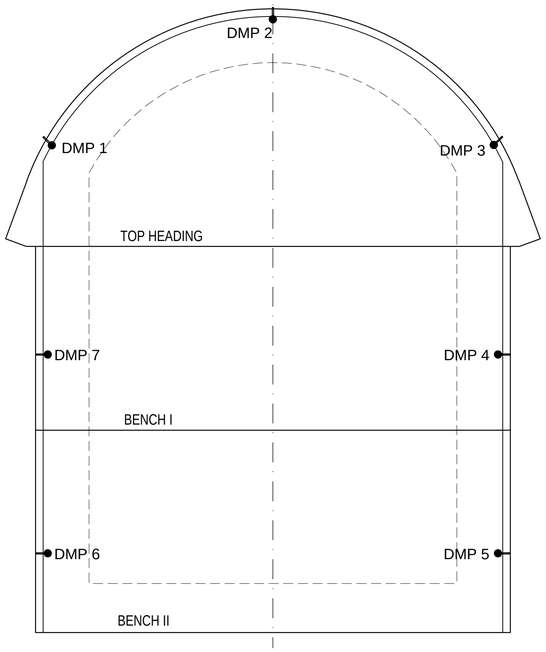
DIVERSION TUNNEL - Primary Support
Downstream Cross Section (Type C)
Support type Fb

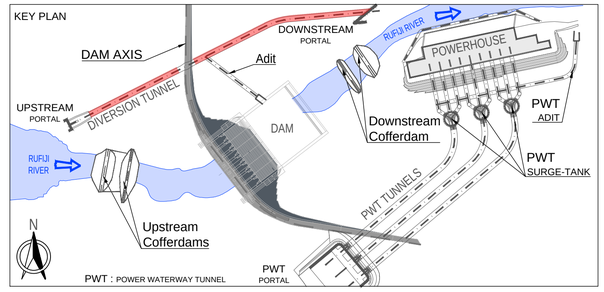
Detail Design

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Document no. RUF-SHC330-ULX-&CTA010-001003	Rev. 00	PAGE NO. 12

DIVERSION TUNNEL
MONITORING CROSS SECTION S1

SCALE 1:100





LEGEND

TECHNICAL CHARACTERISTICS	
DMP ⊸● REFERENCE PLOT FOR OPTICAL CONVERGENCE MEASUREMENTS TYPE: Galvanized rebar, 250mm long and 22mm diameter usable also with tape distometer SENSOR: Removible optical target 40x40 mm	

GENERAL NOTES:

1. ALL INSTRUMENTS TO BE INSTALLED AS SOON AS POSSIBLE AFTER EXCAVATION OR AS DIRECTED ON SITE.
2. THE OPTICAL TARGET (DMP) CAN BE INTEGRATED DURING CONSTRUCTION AND RELOCATED ALONG TUNNEL PERIMETER ACCORDING TO THE REAL ARRANGEMENT OF TOP HEADING AND BENCHING EXCAVATION.
3. THE INSTALLATION POSITIONS OF THE VARIOUS MONITORING SECTIONS ALONG THE DIVERSION TUNNEL AND INTERMEDIATE ADIT ARE DEFINED ON THE BASIS OF THE PREVIEW GROUND CONDITION AND CAN BE REASONABLY UPDATED ON THE BASIS OF THE ACTUAL ENCOUNTERED CONDITIONS.
4. THE MONITORING INSTRUMENTED SECTION TYPE HAVE BEEN DEFINED:
   S1: EVERY 25-100 M OF TUNNELS DEPENDING ON THE SURROUNDING ROCK CONDITION.

0 1 2 5m

GRAPHIC SCALE 1:100

READING FREQUENCY
Minimum reading frequency: - During excavation and support: Daily - After completion of excavation and support: Daily for the first two months, then weekly if stable. Reading frequency to be increased during critical construction phases, such as (but not limitedly to) tunnelling start.

Originator

The Arab Contractors — OSMAN AHMAD OSMAN & CO. — المقاولون العرب — عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

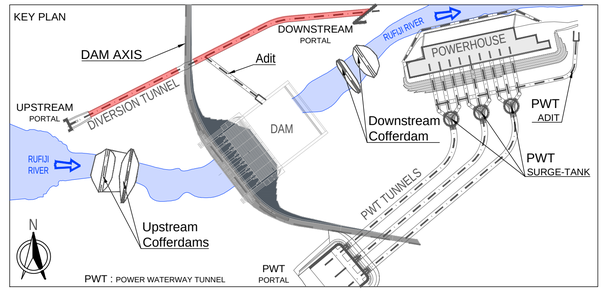
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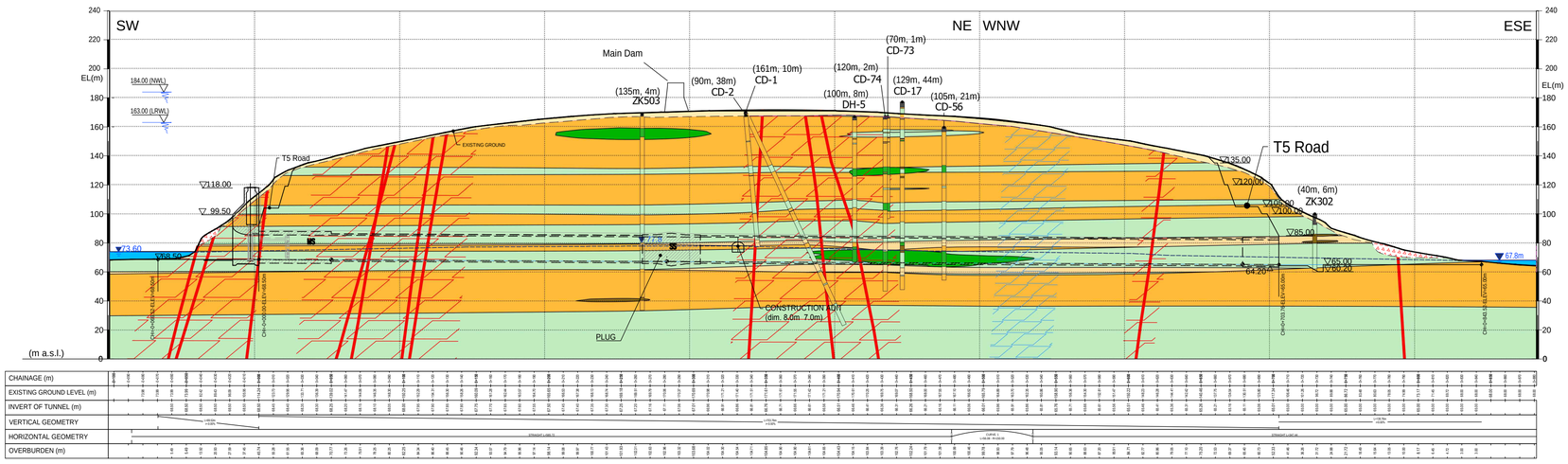
DIVERSION TUNNEL

Monitoring

Detail Design

Type: BLACK	Scale: As Shown	Size: A3
Document no. RUF-SHC330-ULX-&CTA010-001003	Rev. 00	PAGE NO. 13





LONG. SECTION - DIVERSION TUNNEL
Scale 1:2000
From PK -0+100.00 to PK 0+899.31

CHAINAGE (m)
EXISTING GROUND LEVEL (m)
INVERT OF TUNNEL (m)
VERTICAL GEOMETRY
HORIZONTAL GEOMETRY
OVERBURDEN (m)

Overburden (m) 0-10 | 10-20 | 20-50 | >50

Formation: HATAMBULO FORMATION

Lithotype: Sandstone / mudstone and sandy mudstone

Structure: Crushed rock bordering the fault; Fault with brecciá; Medium jointed rock; Heavily jointed rock; Slightly jointed rock

GEOLOGY — Potential geological hazards

A1	Faults
A2	Tectonically disturbed zones
A3	Karstic forms / Cavities / Voids
A4	Water inflow
A5	Abrasive / Resistant/Hard materials
A6	In-situ stress anisotropy
A7	River dynamics
A8	Slope instability
A9	Swelling clay minerals

GEOMECHANICS — Geomechanical classification

	Most likely condition	Subordinate condition
Uniaxial compressive strength - UCS (MPa)**		> 150
		101-150
		51-100
		25-50
		< 25
GSI (Geological Strength Index) *		>55
		41-55
		25-40
		<25

Legend

Quaternary cover

- Recent alluvium: Fine-grained deposits of sandy-silty sediments discontinuously settled along the banks of the Rufiji River
- Eluvial-colluvial cover: Sandy and silty-clayey deposits originated from the weathering of the underlying bedrock of the Karroo rocks
- Rock debris: Poorly sorted and rounded blocks and boulders of sandstone found along the Rufiji riverbanks at the bottom of the sandstone cliffs

Karoo Supergroup
(Late Paleozoic - Early Mesozioc)

Hatambulo Formation

- Sandstone: Coarse to fine arkosic sandstones composed by subangular to round quartz, feldspar and rock fragments. Locally mudstone and closely spaced dark, millimetric to centimetric laminae of coal and mica can occur as lenses with decimetric thickness respectively and limited lateral extent. Internally the sandstones exhibit planar or sigmoidal current-foreset beds and throughs up to 1 m width. Outcrops: plurimetric individual banks in the upper part of the gorge and at the river level
- Sandstone with interbedded layers of mudstone: Coarse to fine arkosic sandstones interbedded with light to dark grey micaceous, sandy mudstones and silty mudstones, sometimes calcareous mudstones
- Mudstone and sandy mudstone: Light to dark grey micaceous, sometimes calcareous mudstones, sandy mudstones and silty mudstones. They often show parallel laminations. Outcrops: metrical and pluri-metrical beds. Occasional decametric sandstone layers
- Mudstones with interbedded layer of sandstone: Light to dark grey micaceous mudstones, sandy mudstones and silty mudstones, sometimes calcareous mudstones, interbedded with fine to coarse sandstone layers
- Fine sandstone and sandy mudstone: Very fine sandstones often interbedded with sandy mudstones in metric levels with laminations and gradational planar lamina and scour-and-fill structures

Symbols

- Fault
- Fracturated zone
- Weak zone ***
- Groundwater level
- River

Boreholes

(120m, 2m) • ZK502 — Boreholes from SHC project (2018 / 2019). Borehole length and distance from section are indicated

(120m, 2m) • CD-24 / DH-5 — Boreholes from tender (1972 / 1980). Borehole length and distance from section are indicated

NOTES:

- The extent of displacement of faults cannot be assessed on the basis of available data (surface geological mapping and existing boreholes)

* Hoek & Marinos (2000 - 2007); Russo (2007)

** Heterogenous mixed face conditions are expected at excavation levels. The ground behaviour is expected to be strictly related to this alternance of thick layers of mudstone and sandstone. The proposed rock strength (likely and subordinated conditions), it is meant to capture this heterogeneity; following a conservative approach the most likely conditions are related to the weaker lithotype.

Originator

The Arab Contractors — OSMAN AHMAD OSMAN & CO. — المقاولون العرب — شركة عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

Detail Design

GEOLOGY,GEOPHYSICAL EXPLORATION,TEST

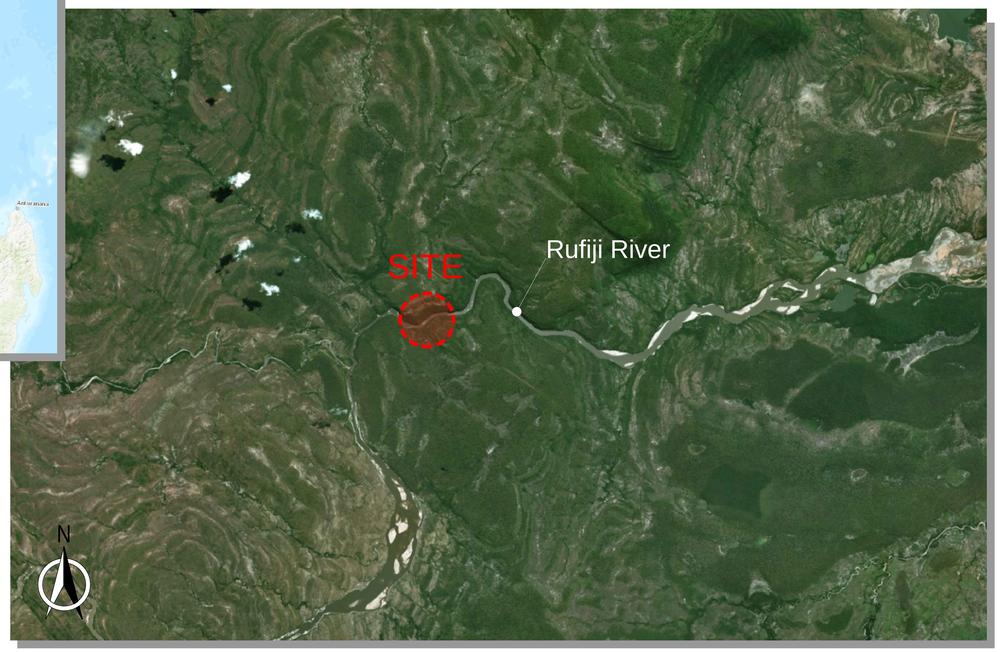
Geological and geomechanical profile of Diversion Tunnel

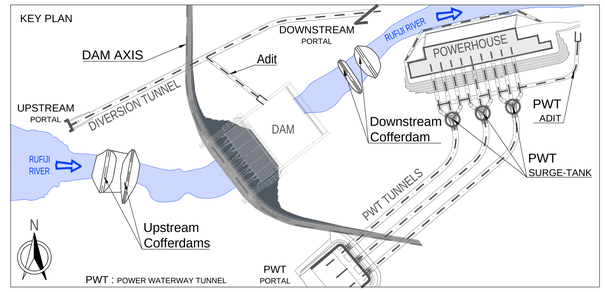
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Document no. RUF-SHC330-ULX-&CTA010-001003	Rev. 00	PAGE NO. 14





LOCATION MAP





GENERAL NOTES:

1. FOR ACCESS ROADS PLEASE REFER TO SPECIFIC DRAWINGS.

Originator

The Arab Contractors
OSMAN AHMAD OSMAN & CO.
المقاولون العرب
عثمان أحمد عثمان وشركاه

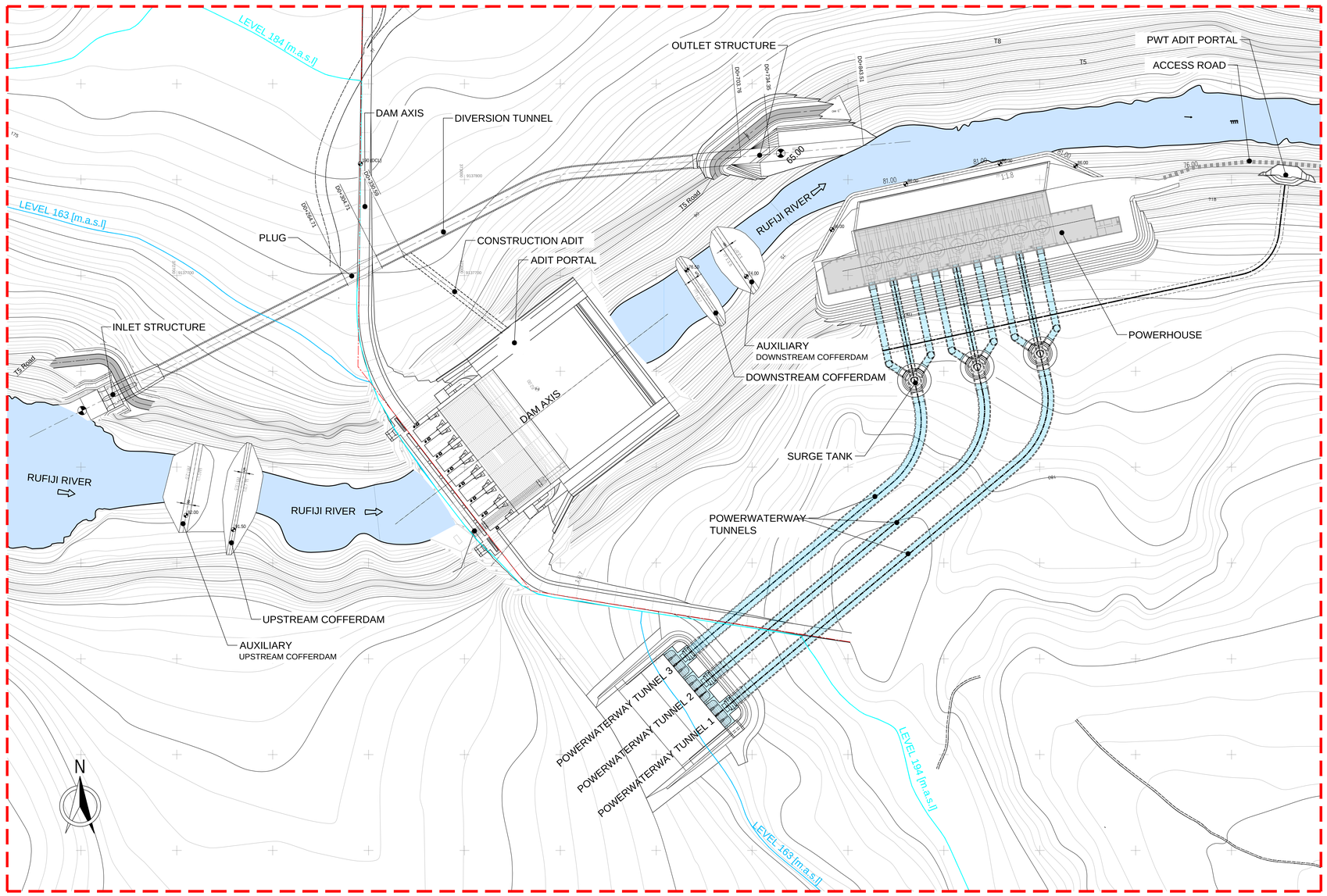
ELSEWEDY ELECTRIC

Title

DIVERSION TUNNEL
General Layout and Site Map Location

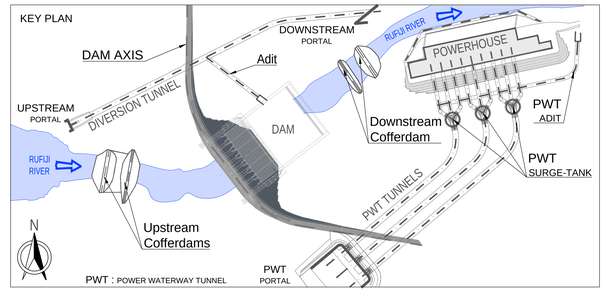
Detail Design

Type: BLACK	Scale: As Shown	Size: A3
Document no. RUF-SHC330-ULX-&CTA010-001003	Rev. 00	PAGE NO. 15



PLAN VIEW

SCALE 1:2500



0 25 50 125m

GRAPHIC SCALE 1:2500

GENERAL NOTES:

1. FOR ACCESS ROADS PLEASE REFER TO SPECIFIC DRAWINGS.

Originator

The Arab Contractors OSMAN AHMAD OSMAN & CO.

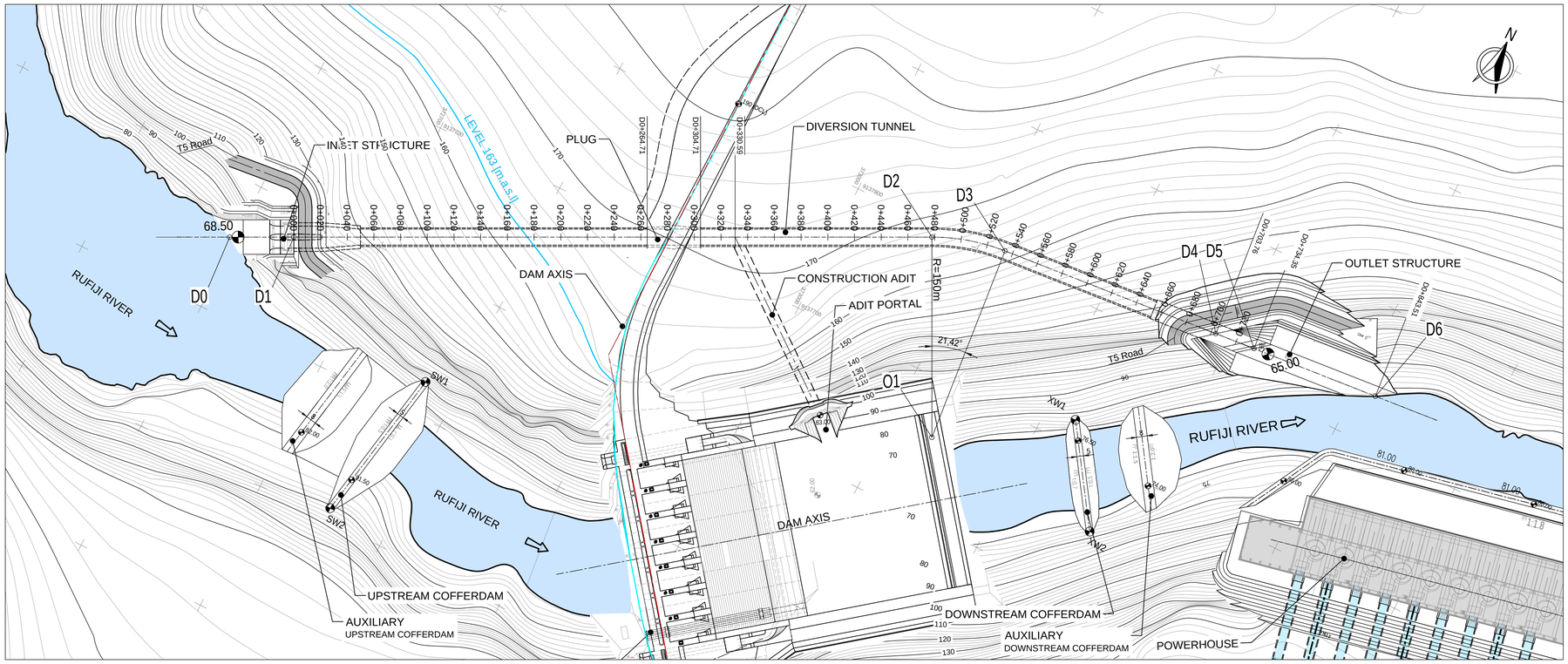
ELSEWEDY ELECTRIC

Title

DIVERSION TUNNEL
General Layout and Site Map Location

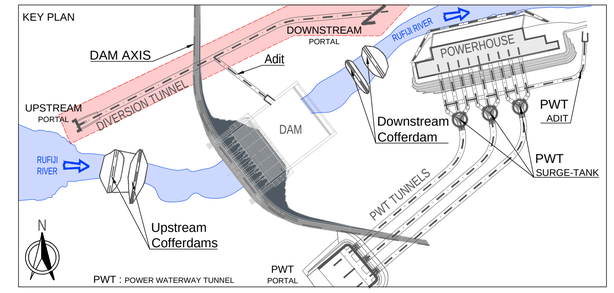
Detail Design

Type: BLACK	Scale: As Shown	Size: A3
Document no. RUF-SHC330-ULX-&CTA010-001003	Rev. 00	PAGE NO. 16



PLAN VIEW

SCALE 1:2000

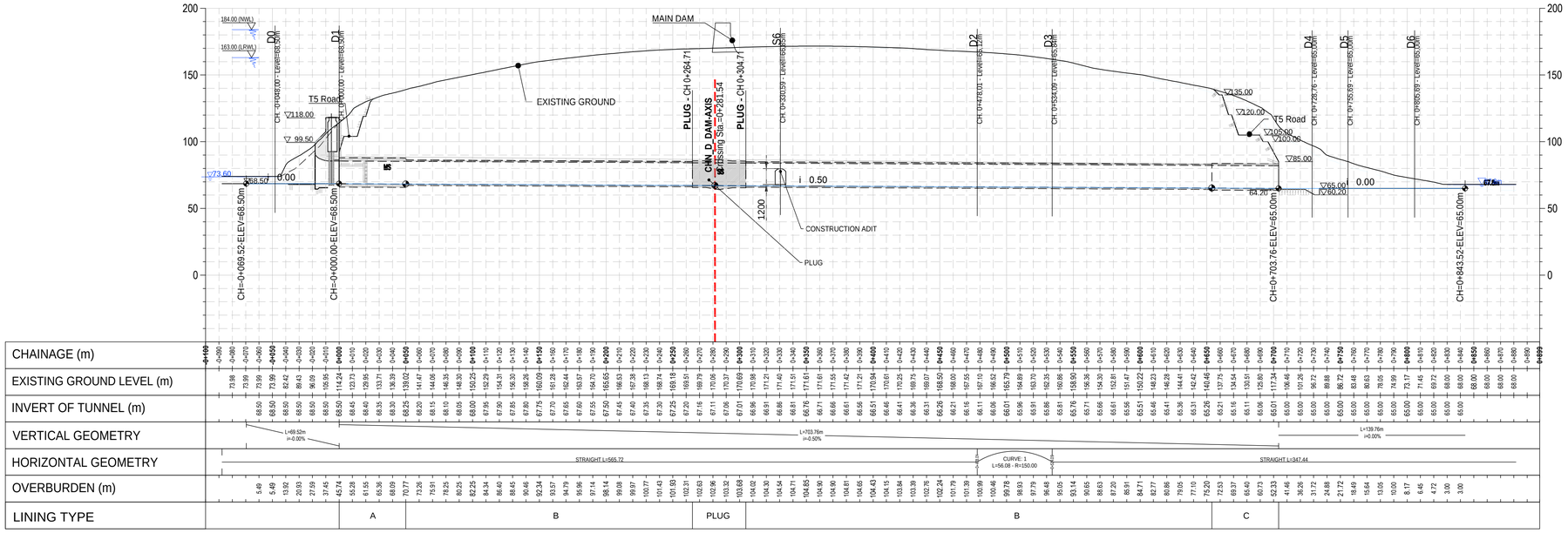


COFFERDAMS - Control Point Coordinates		
Number	X Coordinate(m)	Y Coordinate(m)
SW1	9137528.355	372776.241
SW2	9137402.116	372753.089
XW1	9137718.605	373223.279
XW2	9137648.635	3733270.356

CONTROL POINTS COORDINATES			
	n°	X	Y
	D0	372595.7544	9137556.1351
	D1	372638.6311	9137577.7127
	D2	373065.6181	9137792.5937
	D3	373119.2095	9137807.9644
	D4	373313.0521	9137825.9241
	D5	373339.8709	9137828.4090
	D6	373389.6577	9137833.0218
	O1	373133.0496	9137658.6041

GENERAL NOTES:

1. FOR ACCESS ROADS PLEASE REFER TO SPECIFIC DRAWINGS.



DIVERSION TUNNEL - L-PROFILE

SCALE 1:2000

GRAPHIC SCALE 1:2000 (0, 20, 40, 100m)

Originator

The Arab Contractors — Osman Ahmad Osman & Co.

Elsewedy Electric

Title

DIVERSION TUNNEL

Alignment

Plan View and L-Profile

Detail Design

Type: BLACK	Scale: As Shown	Size: A3
Document no. RUF-SHC330-ULX-&CTA010-001003	Rev. 00	PAGE NO. 17

GENERAL

1. COORDINATES ARE TO ARC60 TRANSVERSE_MERCATOR (ARC60) COORDINATE SYSTEM (ZONE 37S).
2. ALL DIMENSIONS ARE IN CENTIMETRES UNLESS NOTED OTHERWISE. ALL LEVELS, METERAGES, STATIONS AND COORDINATES ARE EXPRESSED IN METRES.
3. ALL LOCATIONS, ORIENTATIONS AND LEVELS SHALL BE VERIFIED ON SITE PRIOR TO COMMENCING ANY WORKS.
4. THE NOTES ON SPECIFIC DRAWINGS/DOCUMENTS SHALL TAKE PRECEDENCE OVER THESE GENERAL NOTES.
5. THESE DRAWINGS SHALL BE READ IN CONJUNCTION WITH THE REFERENCE REPORT AND CONTRACTOR DOCUMENTS.

EXCAVATION AND SUPPORT

1. THE SUPPORT SECTIONS AND THEIR DISTRIBUTIONS ALONG THE TUNNEL ARE DEFINED ACCORDING TO DATA FROM SITE INVESTIGATIONS AVAILABLE AT TIME OF DESIGN. THEY CAN BE SUBJECTED TO MODIFICATIONS ACCORDING TO MONITORING DATA AND CONDITIONS ENCOUNTERED IN THE CONSTRUCTION STAGE (OBSERVATIONAL METHOD).
2. PRIMARY SUPPORT SHALL BE INSTALLED AS PART OF THE EXCAVATION AND SUPPORT CYCLE CLOSE TO THE TUNNEL FACE.
3. FOR THE TEMPORARY ADIT TUNNEL AND THE DIVERSION TUNNEL WITH CAST IN SITU CONCRETE FINAL LINING INSTALLED, PRIMARY SUPPORT SHALL BE CONSIDERED AS TEMPORARY WITH REFERENCE TO THE DESIGN LIFE OF THE INDIVIDUAL SUPPORT ELEMENTS (REFERENCE SERVICE LIFE OF SUPPORT ELEMENTS 10 YEARS). IF IT IS NECESSARY TO ENSURE LONG TERM STABILITY IN THE ZONE OF THE ADIT NOT FILLED WITH CONCRETE (PLUG), INTEGRATIVE EXCAVATION SUPPORT ELEMENTS SHALL BE APPLIED .
4. THE GEOLOGY OF THE FACE AND FRESHLY EXCAVATED SECTION OF TUNNELS SHALL BE MAPPED BY GEOLOGIST OR ENGINEERING GEOLOGIST PRIOR TO THE APPLICATION OF SHOTCRETE.
5. ADDITIONAL EXCAVATION SUPPORTS SHALL BE INSTALLED AS REQUIRED TO ENSURE THE STABILITY OF THE EXCAVATIONS, TO SECURE ANY OBSERVED GEOLOGICAL FEATURES.
6. EXCAVATION AND SUPPORT CLASSES SHALL BE APPLIED AS PER THE DRAWINGS AND ACTUAL GROUND CONDITION.
7. PROBING IS REQUIRED TO IDENTIFY WEAK ZONES AHEAD OF THE FACE AND INVESTIGATE GROUNDWATER INFLOW CONDITION. IF NECESSARY, GROUTING SHALL BE CARRIED OUT TO REDUCE THE PERMEABILITY OR IMPROVE GEOTECHNICAL PROPERTIES OF THE GROUND.

GROUNDWATER AND DRAINAGE

1. PROVISIONS FOR THE RELIEF OF GROUNDWATER SHALL BE INSTALLED AS PER THE DRAWINGS.
2. DRAINS IN THE TUNNEL FACE TO BE APPLIED IF WATER INCOMES FROM THE TUNNEL FACE (OR FROM PROBE HOLES) AND/OR IF NEEDED AS PER THE INSTRUCTIONS OF THE DESIGNER REPRESENTATIVE ON SITE.
3. A REGULAR PATTERN OF WEEP HOLES (L=1m) SHALL BE INSTALLED AT THE END OF THE PRIMARY SUPPORT INSTALLATION TO RELEIVE WATER PRESSURE FROM BEHIND THE SHOTCRETE.

SHOTCRETE

1. SHOTCRETE TYPES AND ASSOCIATED AND PERFORMANCE REQUIREMENTS ARE AS PER THE FOLLOWING TABLE:

TYPE	f'c = 20
CYLINDER STRENGTH (MPa)	20

2. SHOTCRETE IS INTENDED TO BE REINFORCED WITH STEEL WIREMESH OR, ALTERNATIVELY, WITH 35kg/m^3 OF STEEL FIBERS.
3. A MINIMUM THICKNESS OF SHOTCRETE SHALL BE PROVIDED AS SHOWN IN DRAWINGS.
4. A FIRST LAYER OF SHOTCRETE (MINIMUM THICKNESS 50MM) SHALL BE APPLIED IMMEDIATELY AFTER THE EXCAVATION FOR SAFETY. A LAST LAYER OF SHOTCRETE SHALL BE APPLIED AS COVER OF THE SUPPORTS INSTALLED.

ROCK REINFORCEMENT

1. ROCK REINFORCEMENT TYPES AND ASSOCIATED PERFORMANCE REQUIREMENTS ARE AS PER THE FOLLOWING TABLE:

TYPE	1	2	3
	DEFORMED BAR WITH CEMENT GROUT	DEFORMED BAR WITH CEMENT GROUT (SPILING)	SELF DRILLING GROUTED BOLT
BOLT DIAMETER (mm)	25	32	32
MATERIAL	ASTM A615 Grade 60 (420MPa)	ASTM A615 Grade 60 (420MPa)	Type IBO 32N or equivalent
APPLICATION	ROCK	WEAK ROCK	SOIL/WEAK ROCK

2. FOR ROCK BOLTS ALL END HARDWARE SHALL BE EMBEDDED WITHIN SHOTCRETE OR CONCRETE WITH A MINIMUM COVER.

CONCRETE

1. REINFORCED CONCRETE SHALL COMPLY WITH ACI 318 UNLESS NOTED OTHERWISE.
2. CONCRETE CHARACTERISTIC CYLINDER STRENGTH , IF NOT STATED ON THE DRAWINGS, SHALL BE f'c=25MPa.

REINFORCEMENT

1. THE GRADE OF REINFORCEMENT, IF NOT STATED ON THE DRAWINGS, SHALL BE GRADE 60 (420 MPa) CONFORMING TO ASTM A615.

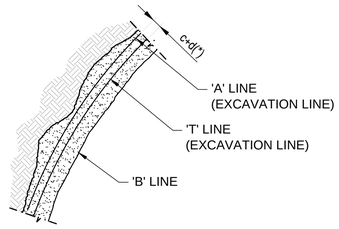
DEFINITIONS

'A' LINE — DEFINES THE EXCAVATION LINE WITHIN WHICH NO UNEXCAVATED MATERIAL SHALL ENCROACH INCLUDING ALL CONSTRUCTION (c) AND DEFORMATION (d) TOLERANCES.

'T' LINE — DEFINES THE THEORETICAL EXCAVATION LINE EXCLUDING ALL CONSTRUCTION AND DEFORMATION TOLERANCES. THIS LINE APPEARS IN ALL THE SUPPORT SECTION DRAWINGS.

'B' LINE — DEFINES THE THEORETICAL INTRADOS OF THE PRIMARY SUPPORT WITHIN WHICH NO ROCK REINFORCEMENTS OR SHOTCRETE WITH THE EXCEPTION OF ROCKBOLT END HARDWARE AND ASSOCIATED SHOTCRETE COVER SHALL ENCROACH.

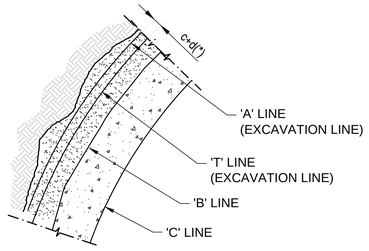
'C' LINE — DEFINES THE MINIMUM THEORETICAL PROFILE WITHIN WHICH NO LINING OR SUPPORT ELEMENT IS PERMITTED TO ENCROACH.



EXCAVATION AND SUPPORT CONTROL LINES
(AREAS WITHOUT FINAL LINING)

(NOT TO SCALE)

*. A PERCENTAGE OF DEFORMATION (d) WILL OCCUR AFTER THE INSTALLATION OF THE PRIMARY SUPPORTS.



EXCAVATION AND SUPPORT CONTROL LINES

(NOT TO SCALE)

*. A PERCENTAGE OF DEFORMATION (d) WILL OCCUR AFTER THE INSTALLATION OF THE PRIMARY SUPPORTS.

DEFORMATION TOLERANCES (d) [mm]

SUPPORT TYPE	DIVERSION TUNNEL	CONSTRUCTION ADIT
B	0-10	0-5
C1	10-20	5-10
C2	20-30	10-20
F	-*	-*

(*) DEFORMATION NOT EXPECTED DUE TO THE INSTALLATION OF THE MICROPILES PIPE ROOF IN THE TUNNEL CROWN AHEAD THE EXCAVATION FACE.

1. A PERCENTAGE OF DEFORMATION (d) WILL OCCUR AFTER THE INSTALLATION OF THE PRIMARY SUPPORTS.

STEEL RIBS

STEEL SET TYPE	MATERIAL	SECTION MODULUS [CM3]
3 BAR LATTICE GIRDER PS 130/187 (2xf25+f32)	ASTM A706 Grade 60 (420MPa)	-
HEB 180 OR EQUIVALENT	ASTM A36 Grade 36 (250MPa)	425,7
HEB 200 OR EQUIVALENT	ASTM A36 Grade 36 (250MPa)	569,6
PLATES	ASTM A36 Grade 36 (250MPa)	-
BOLTS AND STUDS	ASTM A307 Grade A	-
WELDING	AWS D 1.1	-

MICROPILE PIPE ROOF

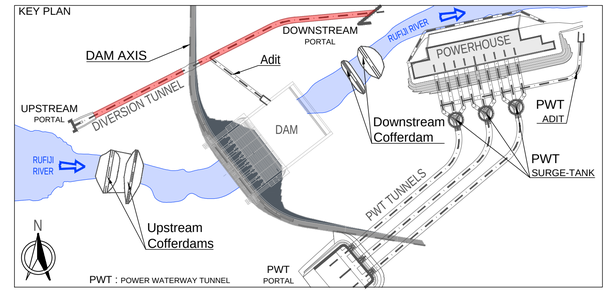
MICROPILES	MATERIAL	LENGTH / OVERLAP (m)
Φ114,3mm, Th=6,3mm	min yielding stress 355MPa	12/3

WIRE MESH

WIRE MESH TYPE	MATERIAL	OVERLAP
200x200Φ6.5	min yielding stress 520MPa	min 30cm

CONSOLIDATION GROUTING

1.GROUND IMPROVEMENT THROUGH CEMENT GROUT INJECTION USING TAM (D = 2 ; VMAX. INJECTED = 100 L/VAL. , CONTROLLED PRESSURE TO PREVENT DAMAGE TO THE LINING)



0 20 40 100m
GRAPHIC SCALE 1:2000

Originator

The Arab Contractors — Osman Ahmad Osman & Co. — المقاولون العرب — عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

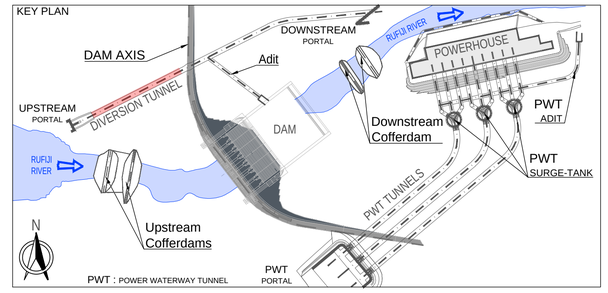
DIVERSION TUNNEL

General Notes

Detail Design

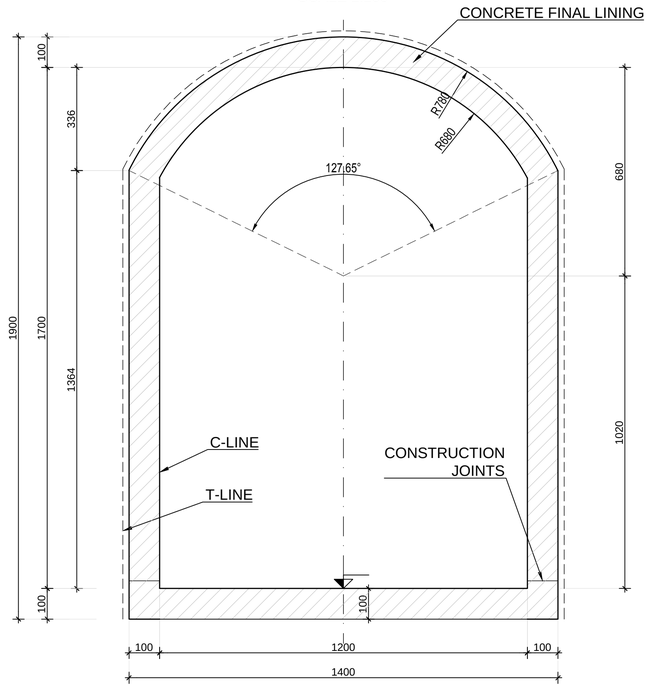
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Document no.	Rev.	PAGE NO.
RUF-SHC330-ULX-&CTA010-001003	Rev. 00	18



FINAL LINING FOR SUPPORT TYPE B-F

SCALE 1:100



GENERAL NOTES:

1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE FINAL LINING SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED



Originator

The Arab Contractors OSMAN AHMAD OSMAN & CO. المقاولون العرب شركة عثمان أحمد عثمان وشركاه

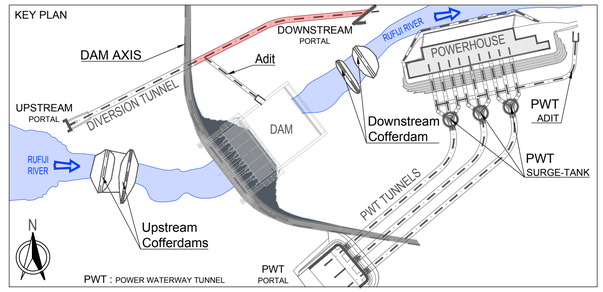
ELSEWEDY ELECTRIC

Title

DIVERSION TUNNEL
Final lining geometry
Upstream cross section (Type B)

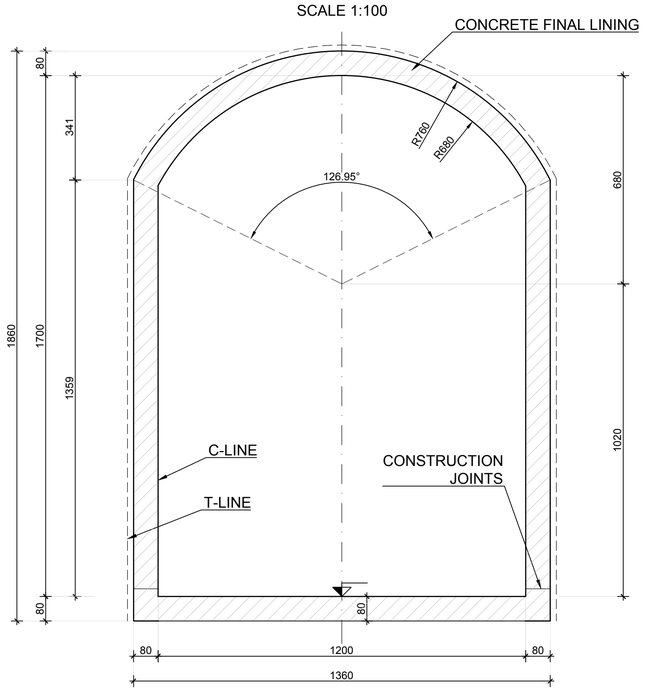
Detail Design

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Document no. RUF-SHC330-ULX-&CTA010-001003	Rev. 00	PAGE NO. 19



FINAL LINING FOR SUPPORT TYPE B-F

SCALE 1:100



GENERAL NOTES:

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2. C-Line: LINE WITHIN WHICH THE FINAL LINING SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED



GRAPHIC SCALE 1:100



GRAPHIC SCALE 1:250

Originator

The Arab Contractors — Osman Ahmad Osman & Co. — المقاولون العرب — عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

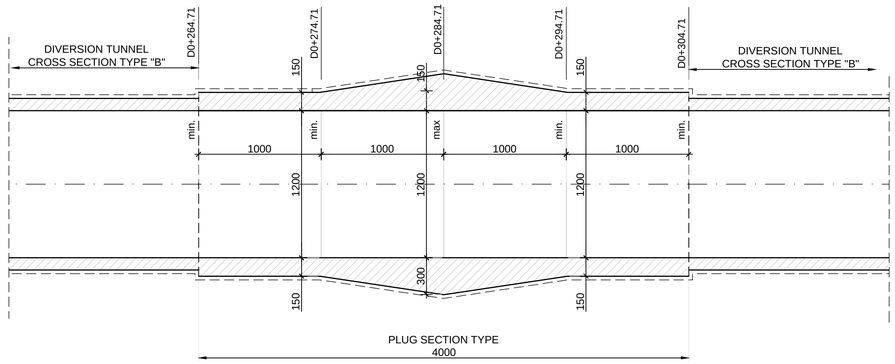
DIVERSION TUNNEL
Final lining geometry
Downstream Cross Section (Type C)

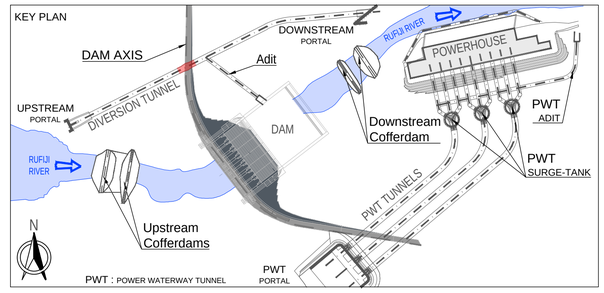
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PLAN VIEW

SCALE 1:250





GENERAL NOTES:

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2. C-Line: LINE WITHIN WHICH THE FINAL LINING SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, ROCK DOWEL AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED.
4. THE ARRANGEMENT OF TOP HEADING MULTI DRIFT AND BENCHING EXCAVATION WILL BE CONFIRMED OR OPTIMIZED BY THE CONTRACTOR ACCORDING TO THEIR AVAILABLE EQUIPMENT AND PREFERRED SOLUTIONS
5. FOR SPECIFIC NOTES REFER TO DRAWING RUFIJI-SHC-ULU-CLH060-00-6/8



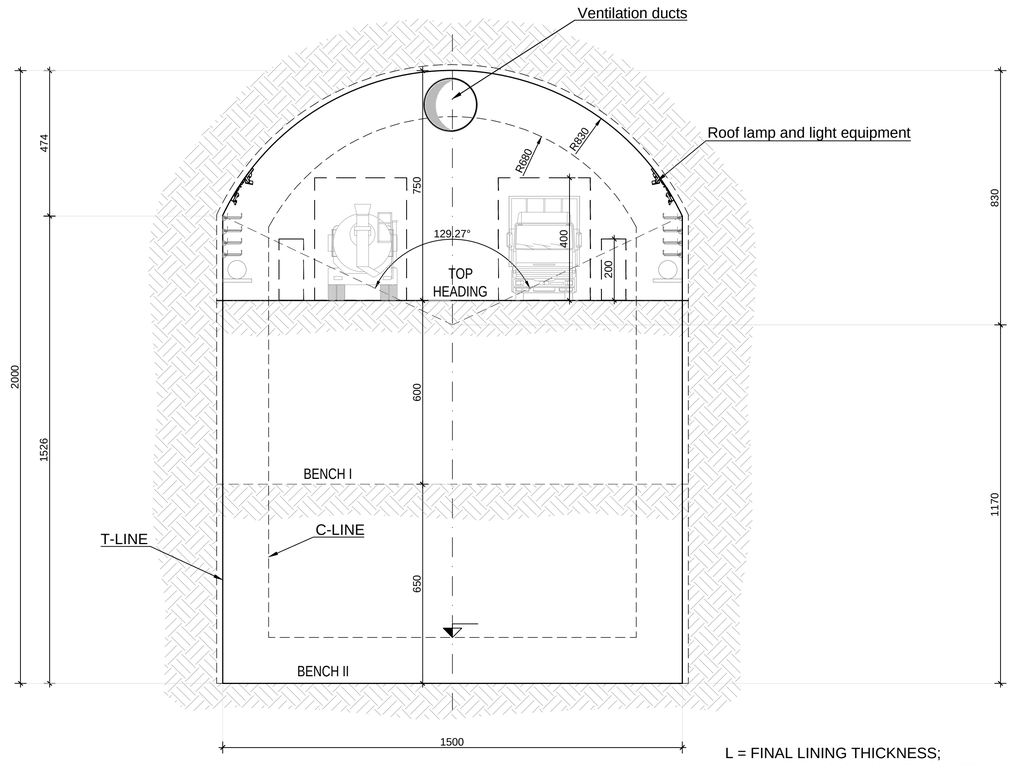
GRAPHIC SCALE 1:250



GRAPHIC SCALE 1:100

TEMPORARY WORKS
FOR SUPPORT TYPE C1-C2 (min)

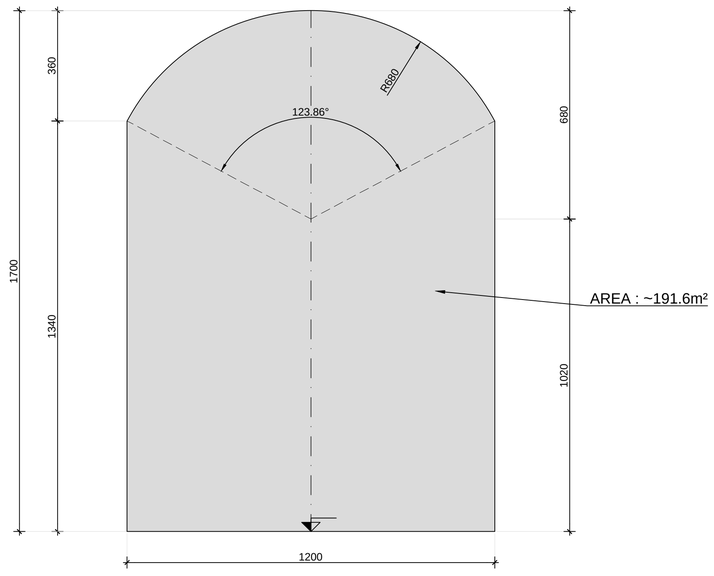
SCALE 1:100



L = FINAL LINING THICKNESS;
X = PRIMARY SUPPORT THICKNESS

OPERATIONAL WORKS
HYDRAULIC CLEARANCE

SCALE 1:100



Originator

The Arab Contractors
OSMAN AHMAD OSMAN & CO.
المقاولون العرب
عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

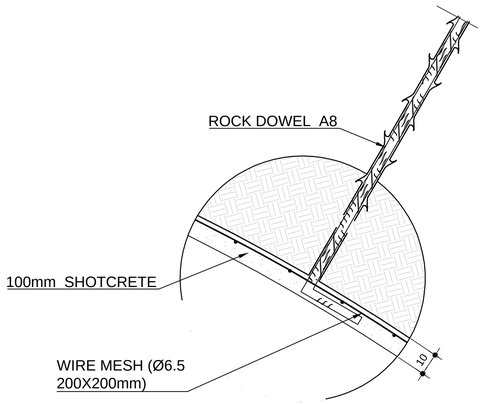
DIVERSION TUNNEL
Typical Plug Cross Section
Operational & temporary works

Detail Design

Type: BLACK	Scale: As Shown	Size: A3
Document no. RUF-SHC340-ULX-&CTA010-001001	Rev. 00	PAGE NO. 01

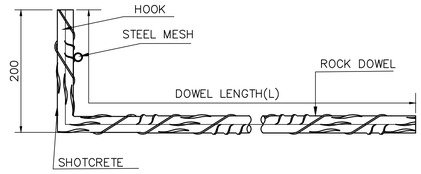
GENERAL NOTES:

1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE FINAL LINING SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, ROCK DOWEL AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED.
4. WATER INFLOW EVALUATION DURING CONSTRUCTION WILL ALLOW TO CONFIRM THE PRESENCE OF DRAINAGE SYSTEM AND/OR TO OPTIMIZE THE NUMBER, LENGTH OF DRAINS AND OVERLAPP. WATER FROM ROCK MASS COLLECTED BY DRAINS MUST BE CHANNELIZED IN DRAINAGE TRENCHES.
5. SUPPORT MEASURES ARE DESIGNED ACCORDING TO AVAILABLE GEOLOGICAL DATA, TO BE VERIFIED ON SITE DURING CONSTRUCTION.
6. TO ENSURE SAFETY FIRST MIN 30mm OF SHOTCRETE SHALL BE INSTALLED ON ALL EXPOSED SURFACE IMMEDIATELY AFTER EXCAVATION.
7. TYPICAL APPLICATION RANGE OF RMR : 40-60.
8. THE ARRANGEMENT OF TOP HEADING MULTI DRIFT AND BENCHING EXCAVATION WILL BE CONFIRMED OR OPTIMIZED BY THE CONTRACTOR ACCORDING TO THEIR AVAILABLE EQUIPMENT AND PREFERRED SOLUTIONS. ACCORDING TO THE DESIGN SOLUTION, ADDITIONAL SUPPORTS SHALL BE INSTALLED ALONG THE TEMPORARY LATERAL SIDEWALLS (I.E. ADDITIONAL SHOTCRETE LAYER WITH ROCK DOWEL AND STEEL RIB ARCH WHERE REQUIRED) TO ENSURE SAFE CONDITIONS DURING.
9. FOR SPECIFIC NOTES REFER TO DRAWING RUFIJI-SHC-ULU-CLH060-00-6/8.
12. THE CHOICE OF THE SUPPORT SECTION TYPE OF DESIGN TO BE APPLIED IS BASED ON GEOMECHANICAL CONDITIONS AT TUNNEL FACE DEFINED BY FACE MAPPING. EACH SECTION TYPE HAS A SPECIFIC FIELD OF APPLICATION BASED ON DEFINED GEOMECHANICAL CONDITIONS. THE SUPPORT VARIABILITY INCLUDED IN EACH SUPPORT SECTION TYPE IS MANAGED ON SITE ON THE BASIS OF VISUAL INSPECTION, EXCAVATION BEHAVIOUR AND MONITORING RESULTS BY THE DESIGN REPRESENTATIVE.



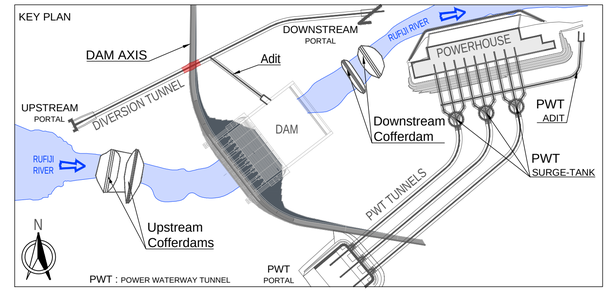
DETAIL "A"

SCALE 1:10



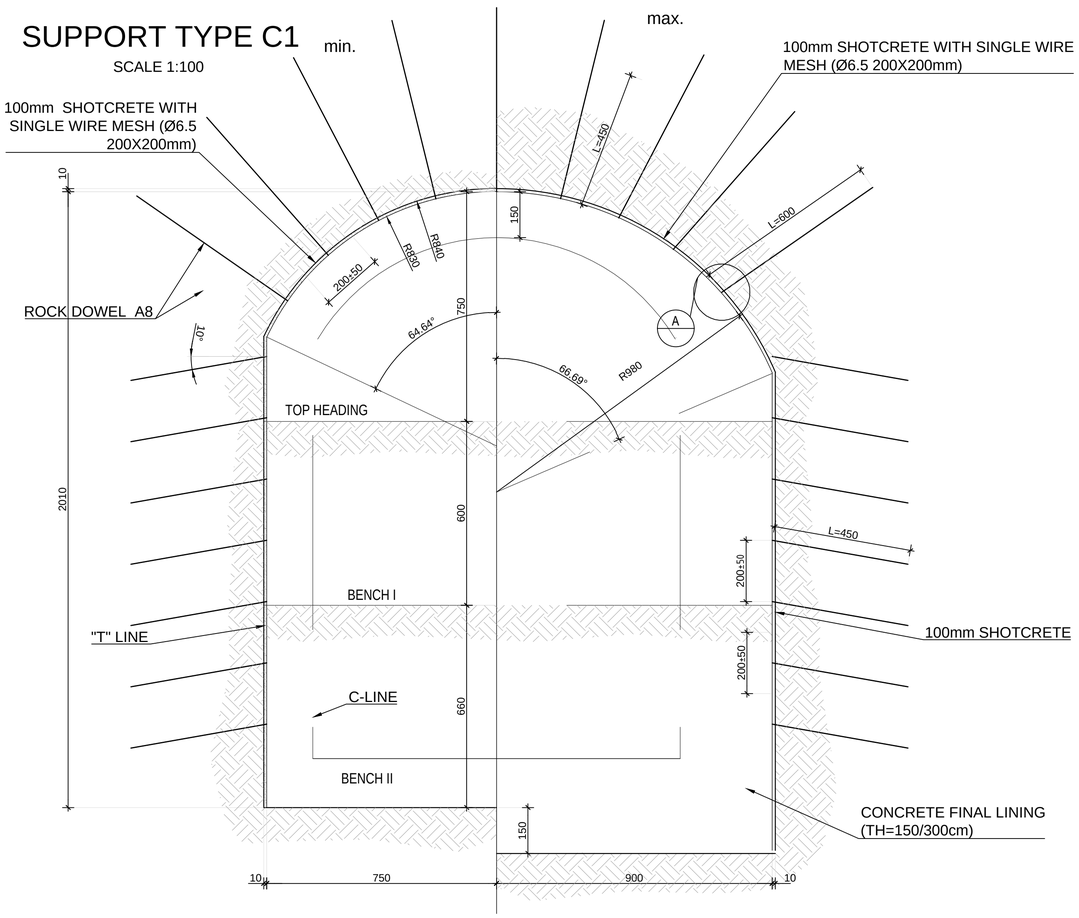
ROCK DOWEL

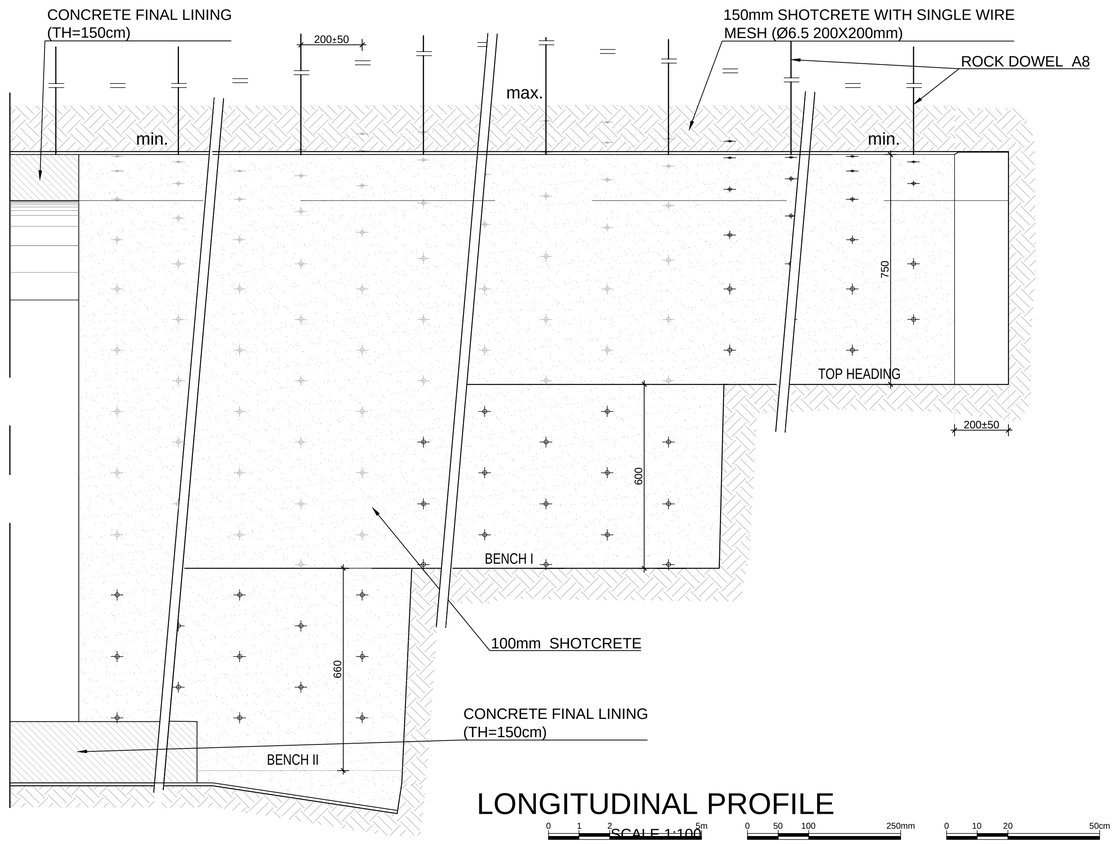
SCALE 1:5
(measured in mm)
The two types of dowel could be choosed for construction



SUPPORT TYPE C1

SCALE 1:100





LONGITUDINAL PROFILE

SCALE 1:100

GRAPHIC SCALE 1:100 (0 1 2 5m) GRAPHIC SCALE 1:5 (0 50 100 250mm) GRAPHIC SCALE 1:10 (0 10 20 50cm)

Originator

The Arab Contractors OSMAN AHMAD OSMAN & CO. المقاولون العرب عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

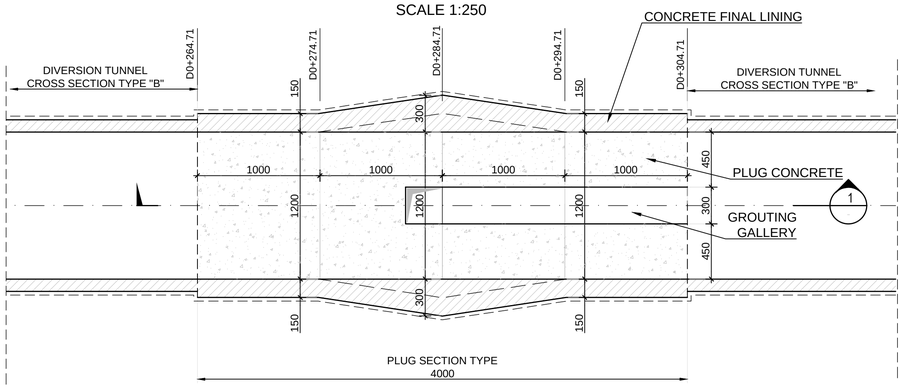
DIVERSION TUNNEL
Primary Support
Plug Section Type - Support type C1

Detail Design

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Document no. RUF-SHC340-ULX-&CTA010-001001	Rev. 00	PAGE NO. 02

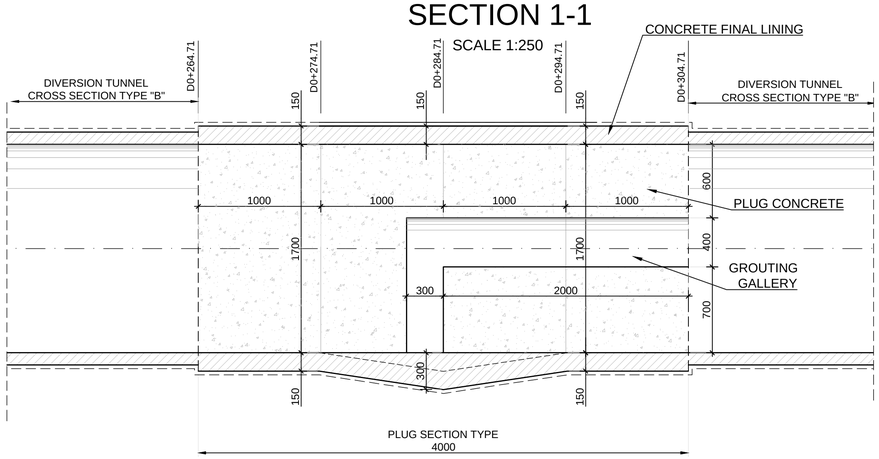
PLAN VIEW

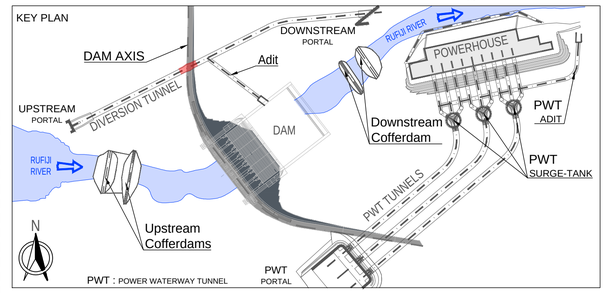
SCALE 1:250

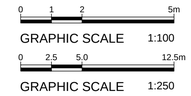


SECTION 1-1

SCALE 1:250





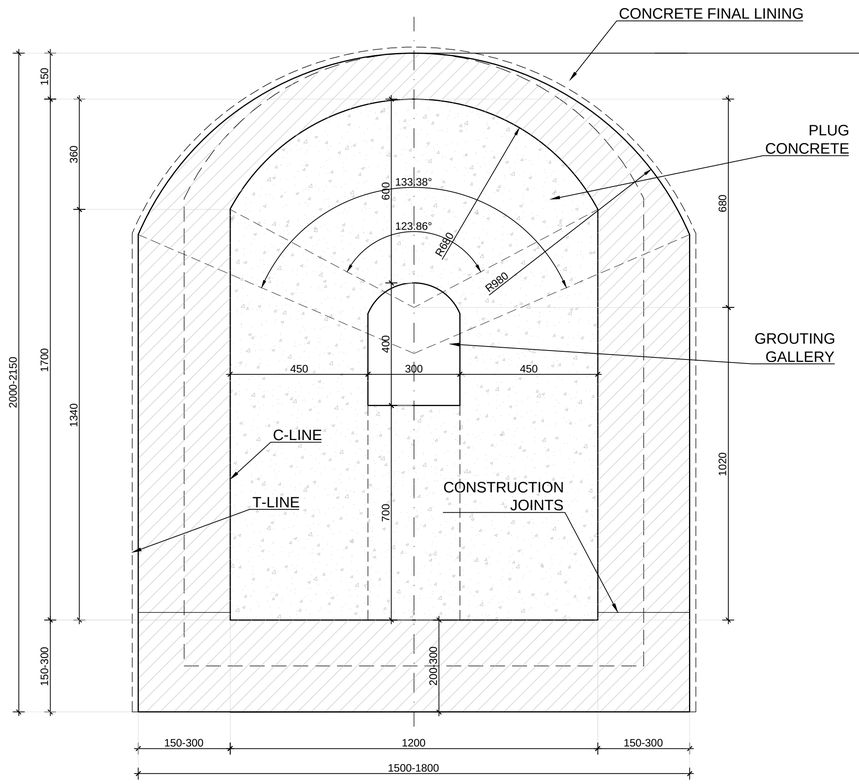


GENERAL NOTES:

1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE FINAL LINING SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF STEEL BARS, ROCK DOWEL AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED

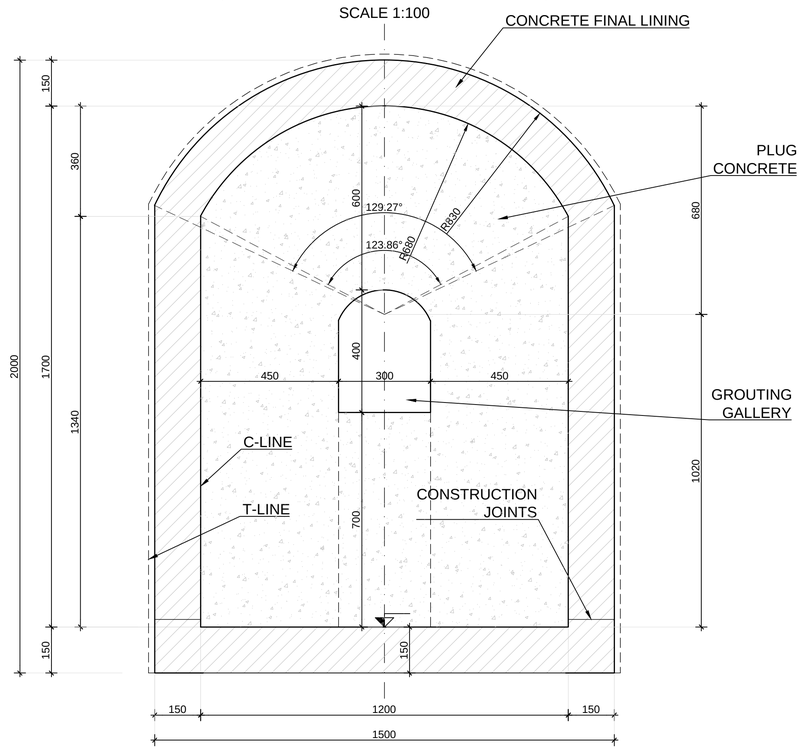
FINAL LINING FOR SUPPORT TYPE C1-C2 (max) (CH 0+284.71)

SCALE 1:100



FINAL LINING FOR SUPPORT TYPE C1-C2 (min) (CH 0+264.71÷0+274.71) (CH 0+294.71÷0+304.71)

SCALE 1:100



Originator

TheArabContractors
OSMAN AHMAD OSMAN & CO.
المقاولون العرب
عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

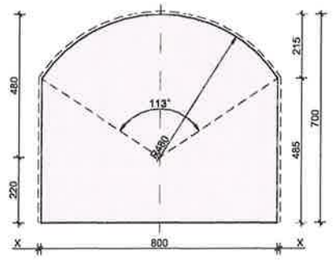
DIVERSION TUNNEL
Final lining geometry
Plug Section Type

Detail Design

Type: BLACK	Scale: As Shown	Size: A3
Document no. RUF-SHC340-ULX-&CTA010-001001	Rev. 00	PAGE NO. 03

INTERMEDIATE ADIT TYPICAL CROSS SECTION CLEARANCE

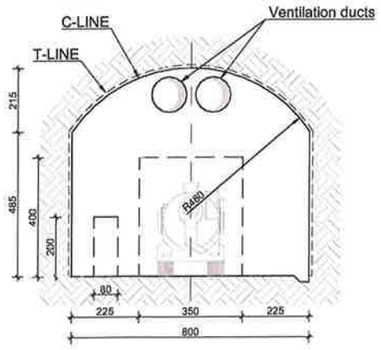
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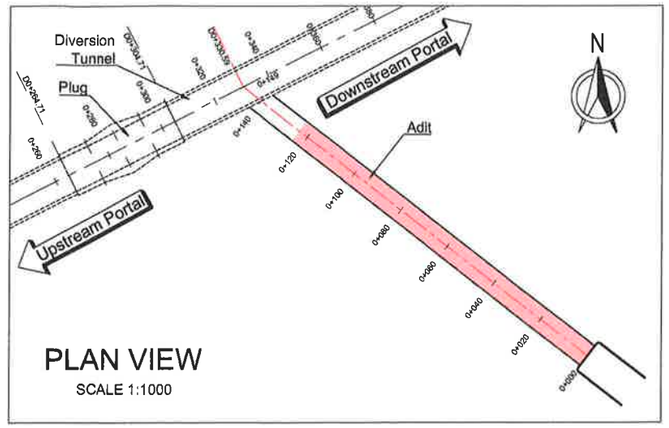


X = PRIMARY SUPPORT THICKNESS

TEMPORARY WORKS FOR SUPPORT TYPE B-C1-C2-Fa

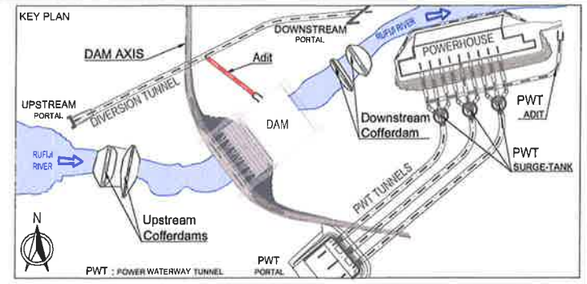
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PLAN VIEW

SCALE 1:1000



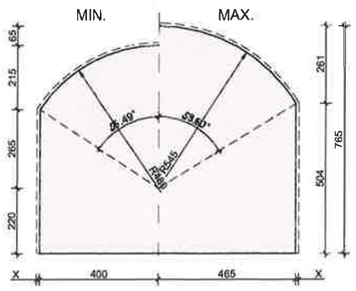
GENERAL NOTES:

1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE PRIMARY SUPPORT SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF ROCK DOWEL AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED.



INTERMEDIATE ADIT TYPICAL CROSS SECTION CLEARANCE

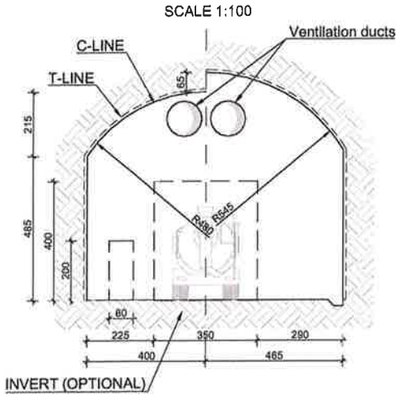
SCALE 1:100



X = PRIMARY SUPPORT THICKNESS

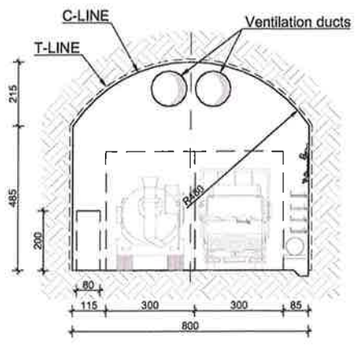
TEMPORARY WORKS FOR SUPPORT TYPE Fb

SCALE 1:100



TEMPORARY WORKS CROSSING TRUCKS AREA

SCALE 1:100



Originator

TheArabContractors OSMAN AHMED OSMAN & CO

ELSEWEDY ELECTRIC

Title

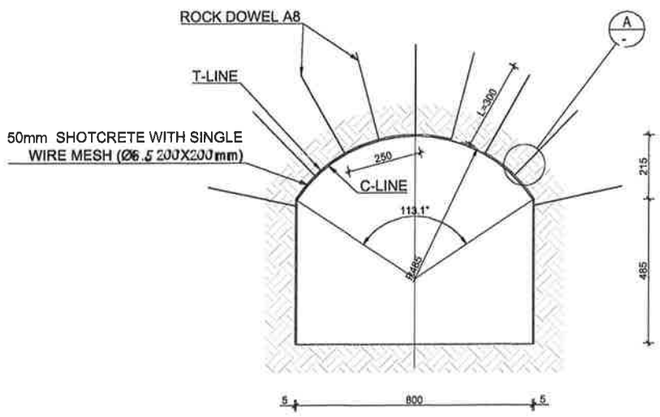
DIVERSION TUNNEL
Intermediate Adit
Typical Cross Sections

Detail Design

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Document no. RUF-SHC360-ULX-&CTA010-001001	Rev. 00	PAGE NO. 01

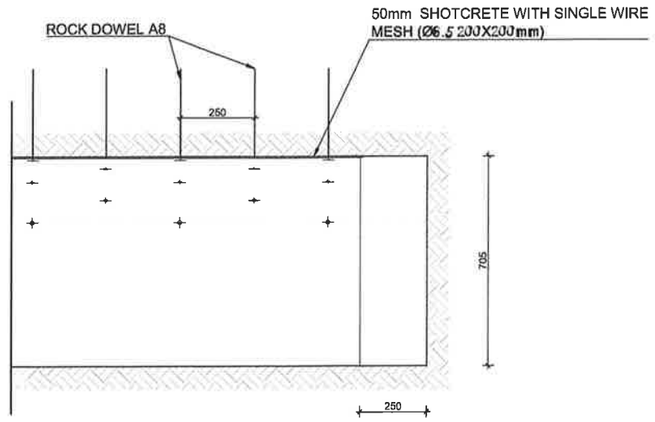
SECTION B

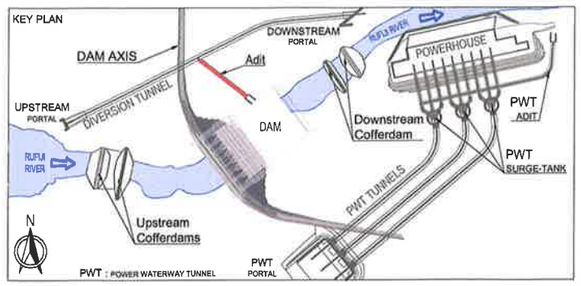
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LONGITUDINAL PROFILE

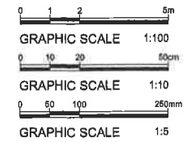
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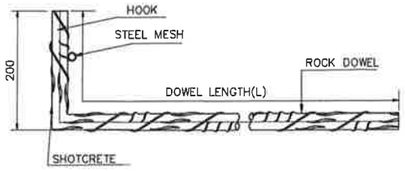




GENERAL NOTES:

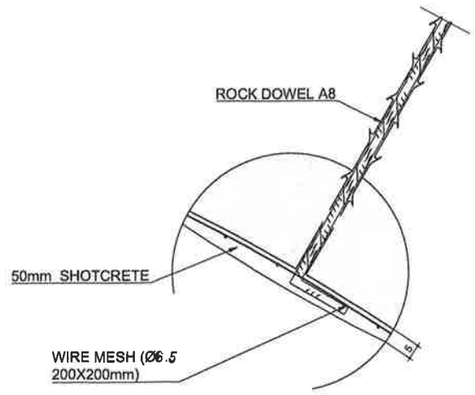
1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE PRIMARY SUPPORT SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF ROCK DOWEL AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED.
4. WATER INFLOW EVALUATION DURING CONSTRUCTION WILL ALLOW TO CONFIRM THE PRESENCE OF DRAINAGE SYSTEM AND/OR TO OPTIMIZE THE NUMBER, LENGTH OF DRAINS AND OVERLAPP. WATER FROM ROCK MASS COLLECTED BY DRAINS MUST BE CHANNELIZED IN DRAINAGE TRENCHES.
5. SUPPORT MEASURES ARE DESIGNED ACCORDING TO AVAILABLE GEOLOGICAL DATA, TO BE VERIFIED ON SITE DURING CONSTRUCTION.
6. TYPICAL APPLICATION RANGE OF RMR : >60.
7. THE CHOICE OF THE SUPPORT SECTION TYPE OF DESIGN TO BE APPLIED IS BASED ON GEOMECHANICAL CONDITIONS AT TUNNEL FACE DEFINED BY FACE MAPPING. EACH SECTION TYPE HAS A SPECIFIC FIELD OF APPLICATION BASED ON DEFINED GEOMECHANICAL CONDITIONS. THE SUPPORT VARIABILITY INCLUDED IN EACH SUPPORT SECTION TYPE IS MANAGED ON SITE ON THE BASIS OF VISUAL INSPECTION, EXCAVATION BEHAVIOUR AND MONITORING RESULTS BY THE DESIGN REPRESENTATIVE.





ROCK DOWEL

SCALE 1:5
(measured in mm)



DETAIL "A"

SCALE 1:10

EXACAVATION METHOD	PRIMARY SUPPORT TYPE B Range of application: 60≤RMR & 4.64≤Q
FULL-FACE EXCAVATION	ROUND LENGHT: 2.5-3.5m
	2+2 DRAINAGE ϕ2", L=12-15m, av=10° - ah=5°, OVERLAPPING 5m
	50mm SHOTCRETE WITH SINGLE WIRE MESH (ϕ6.5 200X200mm) IN TUNNEL CROWN
	SPOT ROCK DOWEL A8 PATTERN 2.5×2.5m IN THE CROWN, ROCK DOWEL A8 WITH Fy≥ 200KN (DIA.25mm MIN), L=3.0m

Originator

The Arab Contractors — Osman Ahmed Osman & Co

ELSEWEDY ELECTRIC

Title

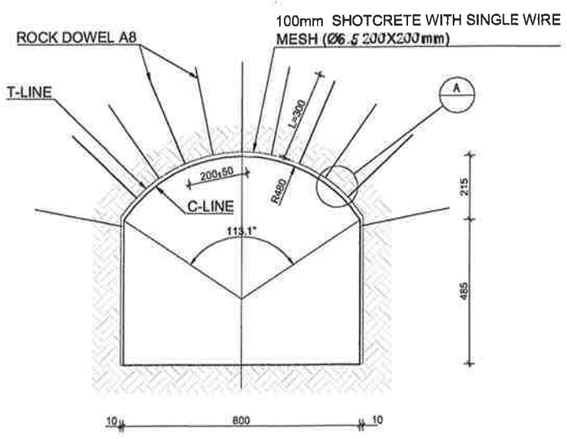
DIVERSION TUNNEL
Intermediate Adit - Primary Support
Support type B

Detail Design

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Document no. RUF-SHC360-ULX-&CTA010-001001	Rev. 00	PAGE NO. 02

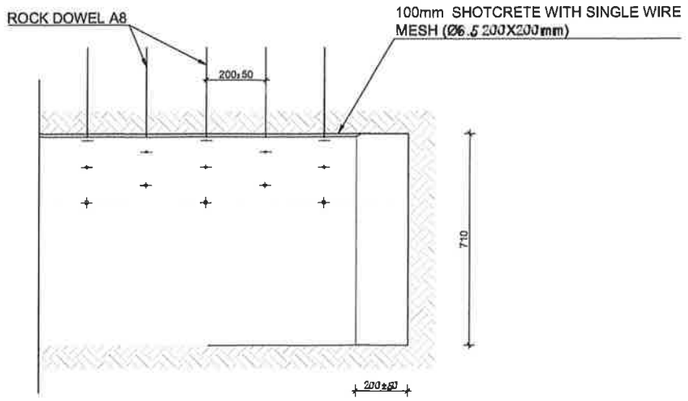
SECTION C1

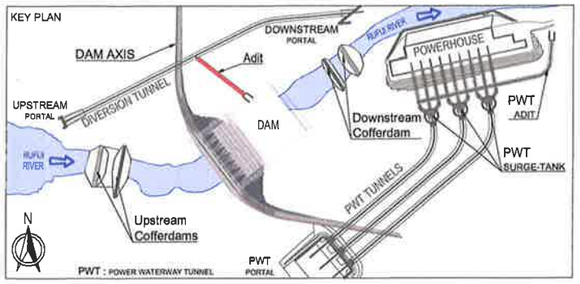
SCALE 1:100



LONGITUDINAL PROFILE

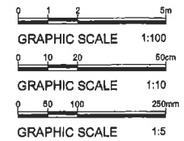
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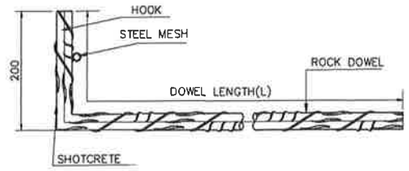




GENERAL NOTES:

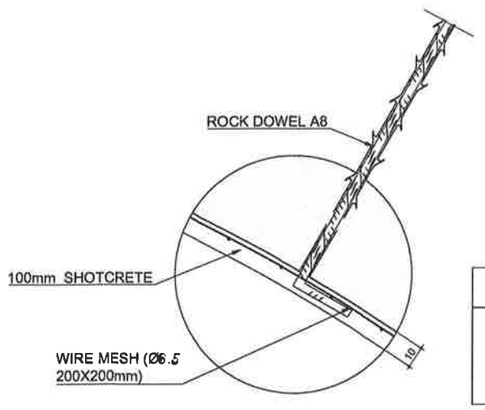
1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE PRIMARY SUPPORT SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF ROCK DOWEL AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED.
4. WATER INFLOW EVALUATION DURING CONSTRUCTION WILL ALLOW TO CONFIRM THE PRESENCE OF DRAINAGE SYSTEM AND/OR TO OPTIMIZE THE NUMBER, LENGTH OF DRAINS AND OVERLAPP. WATER FROM ROCK MASS COLLECTED BY DRAINS MUST BE CHANNELIZED IN DRAINAGE TRENCHES.
5. SUPPORT MEASURES ARE DESIGNED ACCORDING TO AVAILABLE GEOLOGICAL DATA, TO BE VERIFIED ON SITE DURING CONSTRUCTION.
6. TYPICAL APPLICATION RANGE OF RMR : 40-60.
7. THE CHOICE OF THE SUPPORT SECTION TYPE OF DESIGN TO BE APPLIED IS BASED ON GEOMECHANICAL CONDITIONS AT TUNNEL FACE DEFINED BY FACE MAPPING. EACH SECTION TYPE HAS A SPECIFIC FIELD OF APPLICATION BASED ON DEFINED GEOMECHANICAL CONDITIONS. THE SUPPORT VARIABILITY INCLUDED IN EACH SUPPORT SECTION TYPE IS MANAGED ON SITE ON THE BASIS OF VISUAL INSPECTION, EXCAVATION BEHAVIOUR AND MONITORING RESULTS BY THE DESIGN REPRESENTATIVE.





ROCK DOWEL

SCALE 1:5
(measured In mm)



DETAIL "A"

SCALE 1:10

EXACAVATION METHOD	PRIMARY SUPPORT TYPE C1 Range of application: 40≤RMR<60 & 0.215≤Q<4.64
FULL-FACE EXCAVATION	ROUND LENGHT: 2.0±0.50m
	DRAINAGE ϕ50L= 5m, IF REQUIRED.
	100mm SHOTCRETE WITH SINGLE WIRE MESH (ϕ6.5 200X200mm) IN THE CROWN
	SYSTEMATIC ROCK DOWEL A8 PATTERN 2.0±0.50×2.0±0.50m IN THE CROWN , ROCK DOWEL A8 WITH Fy≥200KN (DIA.25mm MIN), L=3.0m

Originator

The Arab Contractors — Osman Ahmed Osman & Co — المقاولون العرب — عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

Title

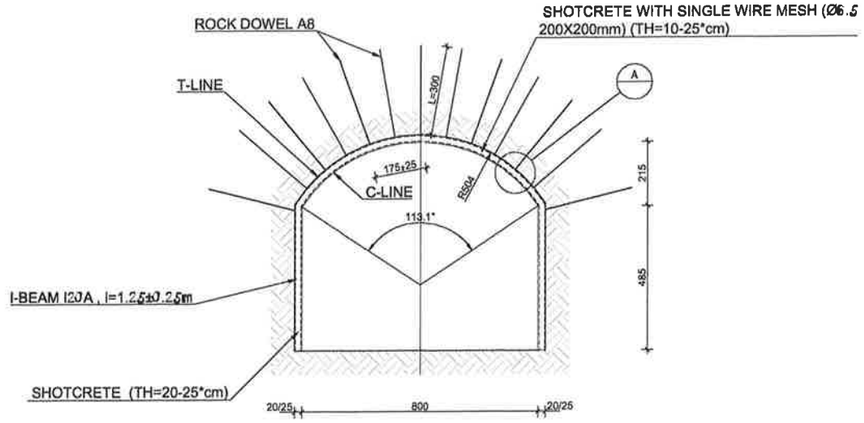
DIVERSION TUNNEL
Intermediate Adit - Primary Support
Support type C1

Detail Design

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Document no. RUF-SHC360-ULX-&CTA010-001001	Rev. 00	PAGE NO. 03

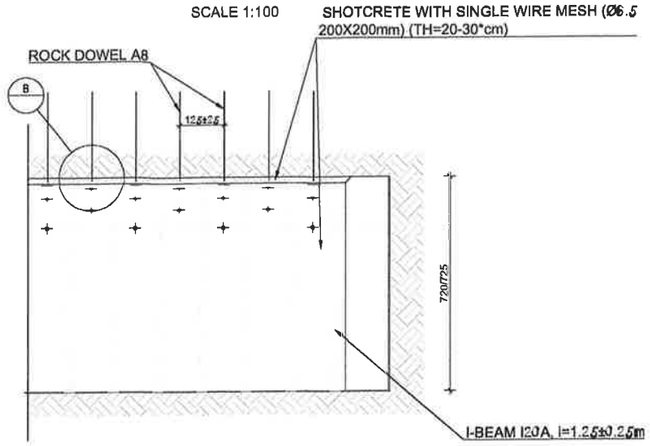
SECTION C2

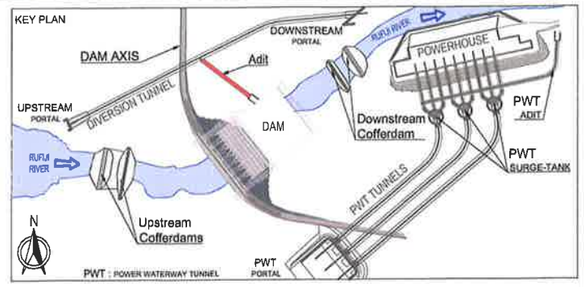
SCALE 1:100



LONGITUDINAL PROFILE

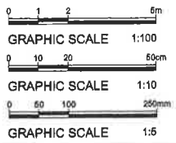
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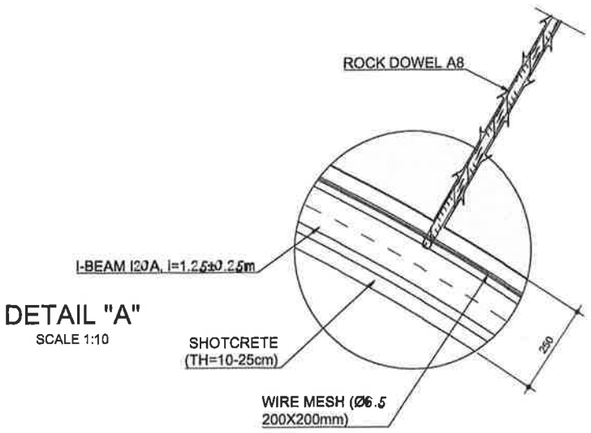




GENERAL NOTES:

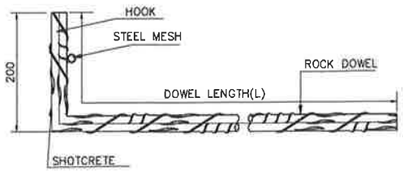
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4. WATER INFLOW EVALUATION DURING CONSTRUCTION WILL ALLOW TO CONFIRM THE PRESENCE OF DRAINAGE SYSTEM AND/OR TO OPTIMIZE THE NUMBER, LENGTH OF DRAINS AND OVERLAPP. WATER FROM ROCK MASS COLLECTED BY DRAINS MUST BE CHANNELIZED IN DRAINAGE TRENCHES.
5. SUPPORT MEASURES ARE DESIGNED ACCORDING TO AVAILABLE GEOLOGICAL DATA, TO BE VERIFIED ON SITE DURING CONSTRUCTION.
6. SHOTCRETE THICKNESS MUST BE INCREASED LOCALLY TO ENSURE MIN 30mm LATTICE GIRDER COVER FOR PROTECTION AGAINST CORROSION.
7. TYPICAL APPLICATION RANGE OF RMR : 20-40.
8. THE CHOICE OF THE SUPPORT SECTION TYPE OF DESIGN TO BE APPLIED IS BASED ON GEOMECHANICAL CONDITIONS AT TUNNEL FACE DEFINED BY FACE MAPPING. EACH SECTION TYPE HAS A SPECIFIC FIELD OF APPLICATION BASED ON DEFINED GEOMECHANICAL CONDITIONS. THE SUPPORT VARIABILITY INCLUDED IN EACH SUPPORT SECTION TYPE IS MANAGED ON SITE ON THE BASIS OF VISUAL INSPECTION, EXCAVATION BEHAVIOUR AND MONITORING RESULTS BY THE DESIGN REPRESENTATIVE.





DETAIL "A"

SCALE 1:10

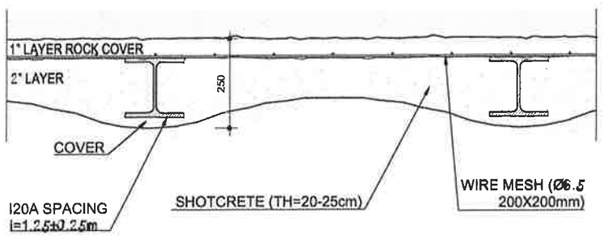


ROCK DOWEL

SCALE 1:5

DETAIL "B"

SCALE 1:10
(measured in mm)



EXACAVATION METHOD	PRIMARY SUPPORT TYPE C2 Range of application: 20≤RMR<40 & 0.01≤Q<0.215
FULL-FACE EXCAVATION	ROUND LENGHT: 2±0.5m
	DRAINAGE ϕ50, L= 5m, IF REQUIRED
	I-BEAM I20A , i=1.25±0.25m
	200 (300)* mm SHOTCRETE WITH SINGLE WIRE MESH (ϕ6.5 200X200mm) IN THE CROWN
	SYSTEMATIC ROCK DOWEL A8 PATTERN 1.75±0.25×1.25±0.25m IN THE CROWN, ROCK DOWEL A8 WITH Fy≥200KN (DIA.25mm MIN), L=3.0m

Originator

The Arab Contractors — Osman Ahmed Osman & Co.

ELSEWEDY ELECTRIC

Title

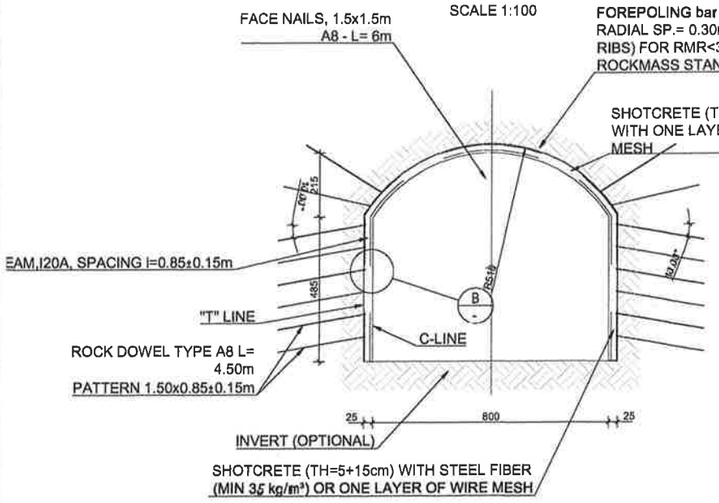
DIVERSION TUNNEL
Intermediate Adit - Primary Support
Support type C2

Detail Design

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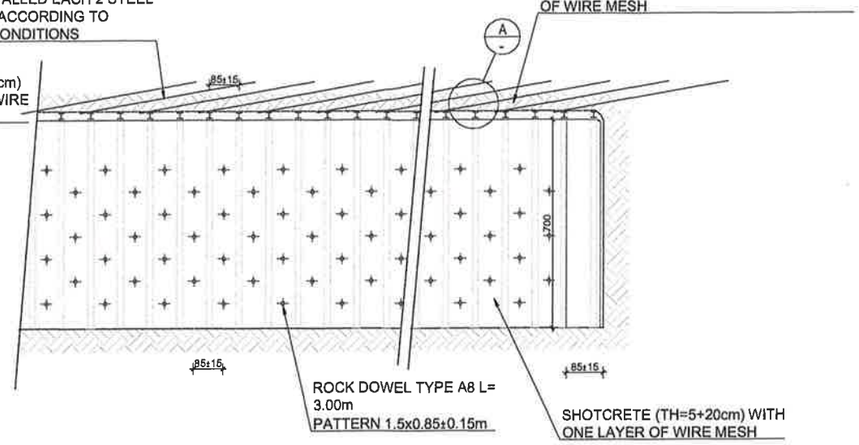
SUPPORT TYPE Fa

SCALE 1:100



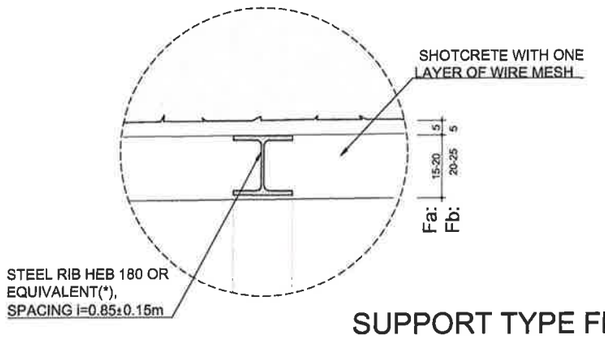
LONGITUDINAL PROFILE

SCALE 1:100



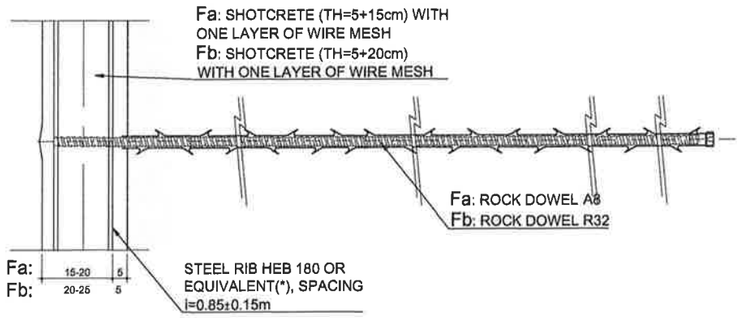
DETAIL "A"

SCALE 1:10



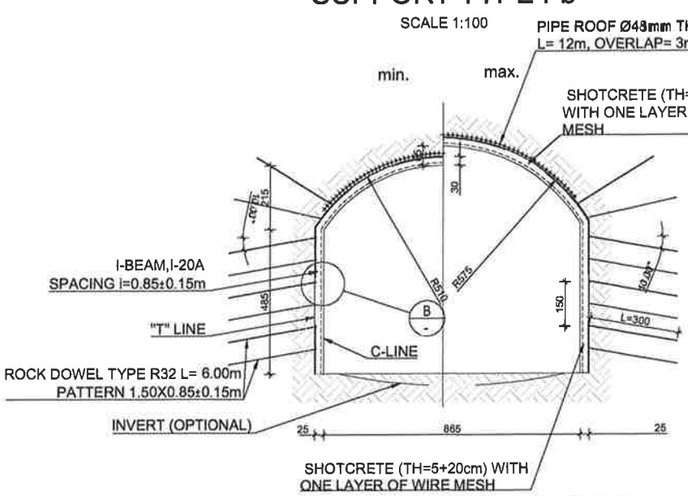
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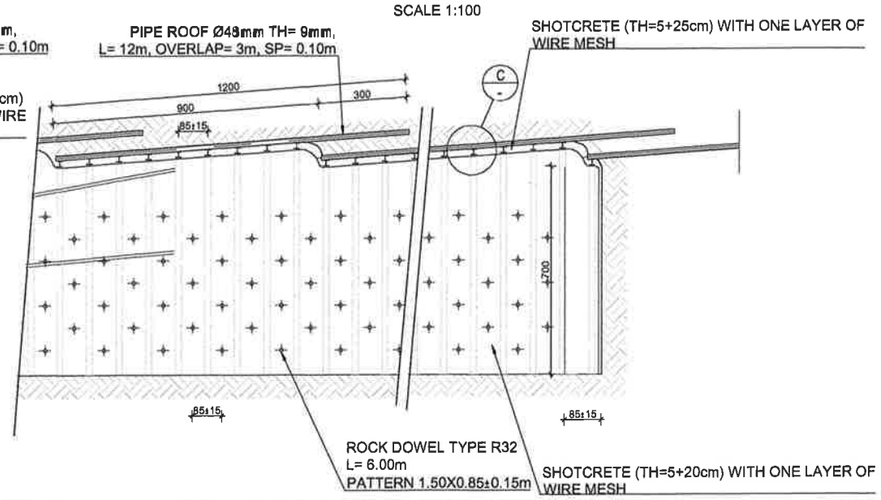
SUPPORT TYPE Fb

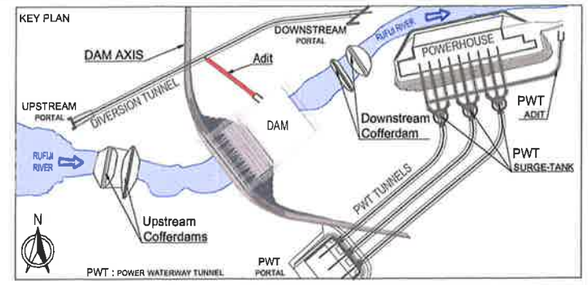
SCALE 1:100



LONGITUDINAL PROFILE

SCALE 1:100





GENERAL NOTES:

1. T-Line: THEORETICAL EXCAVATION LINE WITHOUT CONSTRUCTION AND DEFORMATION TOLERANCE
2. C-Line: LINE WITHIN WHICH THE PRIMARY SUPPORT SHALL BE CONSTRUCTED
3. THE ELEVATIONS, COORDINATES AND CHAINAGES ARE MEASURED IN METERS, THE DIAMETERS OF ROCK DOWEL AND DRAINAGE HOLES ARE IN MILLIMETERS, OTHERS ARE IN CENTIMETERS UNLESS OTHERWISE STATED.
4. WATER INFLOW EVALUATION DURING CONSTRUCTION WILL ALLOW TO CONFIRM THE PRESENCE OF DRAINAGE SYSTEM AND/OR TO OPTIMIZE THE NUMBER, LENGTH OF DRAINS AND OVERLAPP. WATER FROM ROCK MASS COLLECTED BY DRAINS MUST BE CHANNELIZED IN DRAINAGE TRENCHES.
5. SUPPORT MEASURES ARE DESIGNED ACCORDING TO AVAILABLE GEOLOGICAL DATA, TO BE VERIFIED ON SITE DURING CONSTRUCTION.
6. TYPICAL APPLICATION RANGE OF RMR : <20.
7. FACE NAILING DISTRIBUITED SCATTERED AT EACH ADVANCE.
8. THE CHOICE OF THE SUPPORT SECTION TYPE OF DESIGN TO BE APPLIED IS BASED ON GEOMECHANICAL CONDITIONS AT TUNNEL FACE DEFINED BY FACE MAPPING. EACH SECTION TYPE HAS A SPECIFIC FIELD OF APPLICATION BASED ON DEFINED GEOMECHANICAL CONDITIONS, THE SUPPORT VARIABILITY INCLUDED IN EACH SUPPORT SECTION TYPE IS MANAGED ON SITE ON THE BASIS OF VISUAL INSPECTION, EXCAVATION BEHAVIOUR AND MONITORING RESULTS BY THE DESIGN REPRESENTATIVE.



EXACAVATION METHOD	PRIMARY SUPPORT TYPE Fa Range of application: 15<RMR<20 & 0.005<Q<0.01
TOP-HEADING & BENCHING EXCAVATION	ROUND LENGHT: 1±0.5m
	2+2 DRAINAGE ϕ2", L=12-15m, av=10° - ah=5°, OVERLAPPING 5m, IF REQUIRED
	N.20-25 ROCK DOWEL A10 Fy≥300KN OR EQUIVALENT (FOREPOLING), (DIA.32mm MIN), L=6.0m, SPACING 30cm C/C, installed each 2 steel ribs
	FACE NAILS TYPE A8 WITH Fy≥200KN (DIA.25mm MIN), L=, L=6.0m , PATTERN 1.5×1.5m, EACH 3.0m
	STEEL RIB HEB 180 OR EQUIVALENT (*), SPACING i=0.85±0.15m
	5+200mm SHOTCRETE WITH ONE LAYER OF WIRE MESH (Φ6.5 200X200mm)
	SYSTEMATIC BOLTING PATTERN 1.50×0.85±0.15m, A8 WITH Fy≥200KN (DIA.25mm MIN), L=3.0m

(*) IN TERMS OF AREA (Amin=65.3cm²) AND MOMENT OF INERTIA (Jx,min=3931cm⁴)

EXACAVATION METHOD	PRIMARY SUPPORT TYPE Fb Range of application: RMR<15 & Q<0.005
TOP-HEADING & BENCHING EXCAVATION	ROUND LENGHT: 1±0.5m
	2+2 DRAINAGE ϕ2", L=12-15m, av=10° - ah=5°, OVERLAPPING 5m, IF REQUIRED.
	N. 60-65 STEEL UMBRELLA PIPES, Φext=48mm,TH=9mm, L=12.0m (OVERLAPPING 3m), SPACING 0.10m
	FACE NAILS WITH R32 (Fy≥230KN), PATTERN 1.5×1.5m, L=12.0m EACH 9.0m
	STEEL RIB HEB 180 OR EQUIVALENT (*), SPACING i=0.85±0.15m
	50+250mm SHOTCRETE WITH STEEL FIBER (MIN 35 kg/m³) IN THE CROWN AND 50+200mm IN THE SIDEWALLS OR ALTERNATIVELY ONE LAYER OF WIRE MESH (Φ6.5 200X200mm)
	SYSTEMATIC BOLTING PATTERN 1.50×0.85±0.15m, R32 (Fy≥230KN), L=3.0m

(*) IN TERMS OF AREA (Amin=65.3cm²) AND MOMENT OF INERTIA (Jx,min=3931cm⁴)

Originator

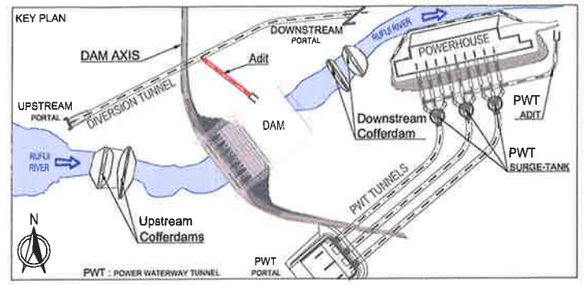
The Arab Contractors — Elsewedy Electric

Title

DIVERSION TUNNEL
Intermediate Adit - Primary Support
Support type Fa & Fb

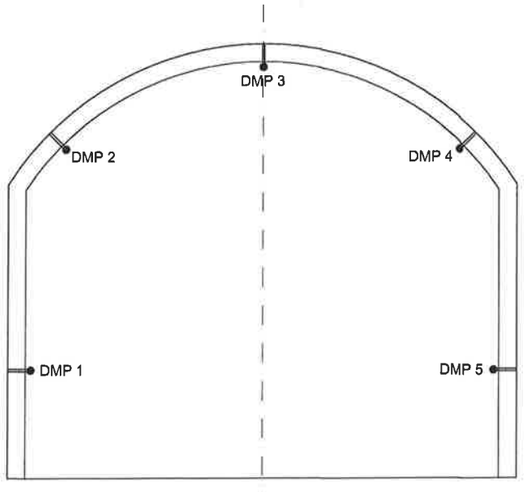
Detail Design

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ADIT
MONITORING CROSS SECTION S1

SCALE 1:50



READING FREQUENCY
Minimum reading frequency: - During excavation and support: Daily - After completion of excavation and support: Daily for the first month, then weekly if stable. Reading frequency to be increased during critical construction phases, such as (but not limitedly to) tunnelling start.

LEGEND

TECHNICAL CHARACTERISTICS	
DMP ⊸●	REFERENCE PLOT FOR OPTICAL CONVERGENCE MEASUREMENTS TYPE: Galvanized rebar, 250mm long and 22mm diameter usable also with tape distometer SENSOR: Removible optical target 40x40 mm

GENERAL NOTES:
1. ALL INSTRUMENTS TO BE INSTALLED AS SOON AS POSSIBLE AFTER EXCAVATION OR AS DIRECTED ON SITE.
2. THE OPTICAL TARGET (DMP) CAN BE INTEGRATED DURING CONSTRUCTION AND RELOCATED ALONG TUNNEL PERIMETER ACCORDING TO THE REAL ARRANGEMENT OF TOP HEADING AND BENCHING EXCAVATION.
3. THE INSTALLATION POSITIONS OF THE MONITORING SECTIONS ALONG THE DIVERSION TUNNEL ARE DEFINED ON THE BASIS OF THE PREVIEW GROUND CONDITION AND CAN BE REASONABLY UPDATED ON THE BASIS OF THE ACTUAL ENCOUNTERED CONDITIONS.
4. THE MONITORING INSTRUMENTED SECTION TYPE HAVE BEEN DEFINED:
   S1: EVERY 30-50 M OF TUNNELS

0 50 100 250cm
GRAPHIC SCALE 1:50

Originator

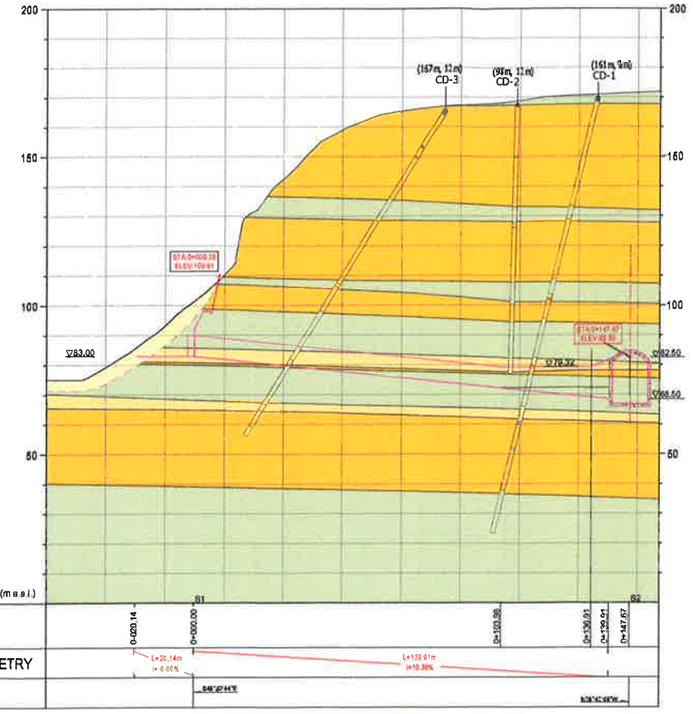
The Arab Contractors — Osman Ahmed Osman & Co. — ELSEWEDY ELECTRIC

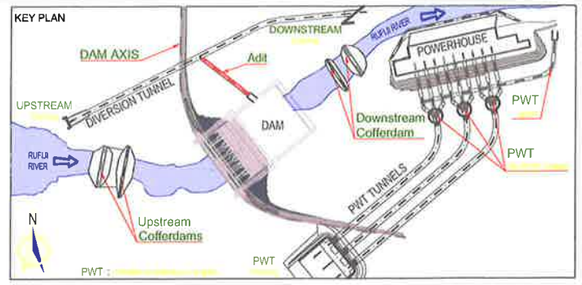
Title

DIVERSION TUNNEL
Intermediate Adit
Monitoring

Detail Design

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Document no. RUF-SHC360-ULX-&CTA010-001001	Rev. 00	PAGE NO. 06





Overburden (m)		0-10 / 10-20 / 20-50 / >50
GEOLOGY	Formation	HATAMBULO FORMATION
	Lithotype	Sandstone / mudstone and sandy mudstone
	Structure	Crushed rock bordering the fault. Fault with breccia; Heavily jointed rock; Medium jointed rock; Slightlyt jointed rock
	Potential geological hazards A1	Faults
	A2	Tectonically disturbed zones
	A3	Karstic forms / Cavities / Voids
	A4	Water inflow
	A5	Abrasive / Resistant/Hard materials
	A6	In-situ stress anisotropy
	A7	River dynamics
	A8	Slope instability
	A9	Swelling clay minerals
GEOMECHANICS	Geomechanical classification: Uniaxial compressive strength - UCS (MPa)** — Most likely condition / Subordinate condition	> 150
		101-150
		51-100
		25-50
		< 25
	GSI (Geological Strength Index) * — Most likely condition / Subordinate condition	>55
		41-55
		25-40
		<25

Legend

Quaternary cover

- Recent alluvium: Fine-grained deposits of sandy-silty sediments discontinuously settled along the banks of the Rufiji River
- Eluvial-colluvial cover: Sandy and silty-clayey deposits originated from the weathering of the underlying bedrock of the Karroo rocks
- Rock debris: Poorly sorted and rounded blocks and boulders of sandstone found along the Rufiji riverbanks at the bottom of the sandstone cliffs

Karoo Supergroup
(Late Paleozoic - Early Mesozioc)

Hatambulo Formation

- Sandstone: Coarse to fine arkosic sandstones composed by subangular to round quartz, feldspar and rock fragments. Locally mudstone and closely spaced dark, millimetric to centimetric laminae of coal and mica can occur as lenses with decimetric thickness respectively and limited lateral extent. Internally the sandstones exhibit planar or sigmoidal current-foreset beds and throughs up to 1 m width. Outcrops: plurimetric individual banks in the upper part of the gorge and at the river level
- Sandstone with interbedded layers of mudstone: Coarse to fine arkosic sandstones interbedded with light to dark grey micaceous, sandy mudstones and silty mudstones, sometimes calcareous mudstones
- Mudstone and sandy mudstone: Light to dark grey micaceous, sometimes calcareous mudstones, sandy mudstones and silty mudstones. They often show parallel laminations. Outcrops: metrical and pluri-metrical beds. Occasional decametric sandstone layers
- Mudstones with interbedded layer of sandstone: Light to dark grey micaceous mudstones, sandy mudstones and silty mudstones, sometimes calcareous mudstones, interbedded with fine to coarse sandstone layers
- Fine sandstone and sandy mudstone: Very fine sandstones often interbedded with sandy mudstones in metric levels with laminations and gradational planar lamina and scour-and-fill structures

Symbols

- Fault
- Fracturated zone
- Weak zone ***
- Groundwater level
- River

Boreholes

- (120m, 2m) ZK502 — Boreholes from SHC project (2018 / 2019). Borehole length and distance from section are indicated
- (120m, 2m) CD-24 / DH-5 — Boreholes from tender (1972 / 1980). Borehole length and distance from section are indicated

NOTES:

- The extent of displacement of faults cannot be assessed on the basis of available data (surface geological mapping and existing boreholes)

* Hoek & Marinos (2000 - 2007); Russo (2007)

** Heterogenous mixed face conditions are expected at excavation levels.
The ground behaviour is expected to be strictly related to this alternance of thick layers of mudstone and sandstone.
The proposed rock strength (likely and subordinated conditions), it is meant to capture this heterogeneity; following a conservative approach the most likely conditions are related to the weaker lithotype.

Originator

The Arab Contractors — Elsewedy Electric

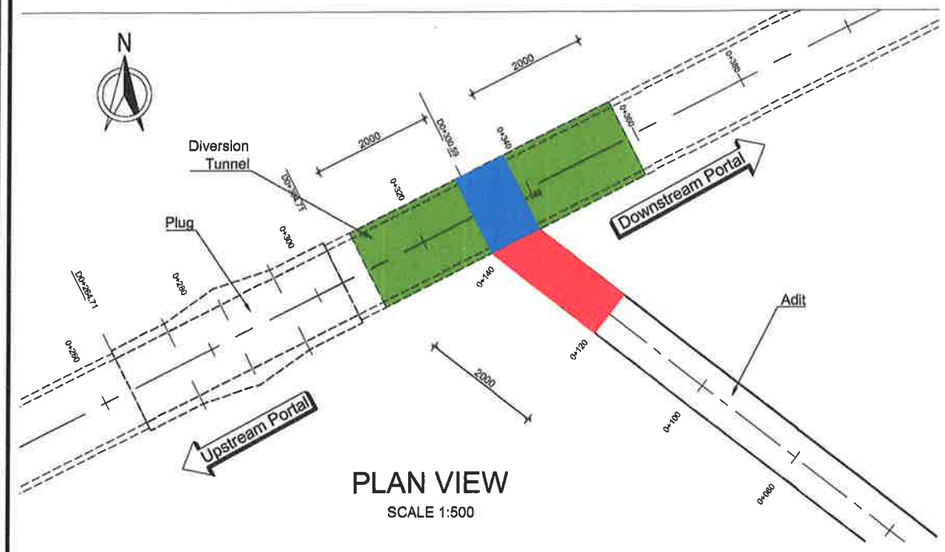
Title

Detail Design

GEOLOGY,GEOPHYSICAL EXPLORATION,TEST

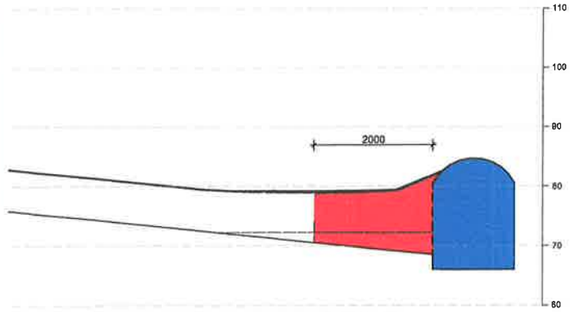
Geological and geomechanical profile of Diversion Tunnel adit

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Document no. RUF-SHC360-ULX-&CTA010-001001	Rev. 00	PAGE NO. 07

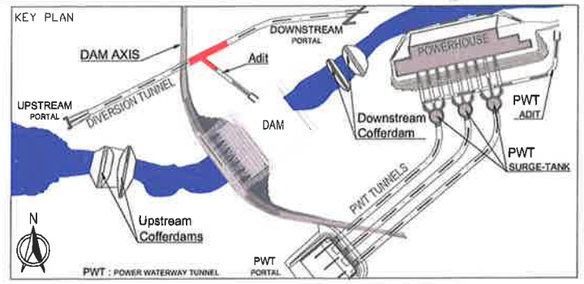


PLAN VIEW
SCALE 1:500

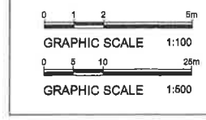
Legend
- Zone 1
- Zone 2
- Zone 3



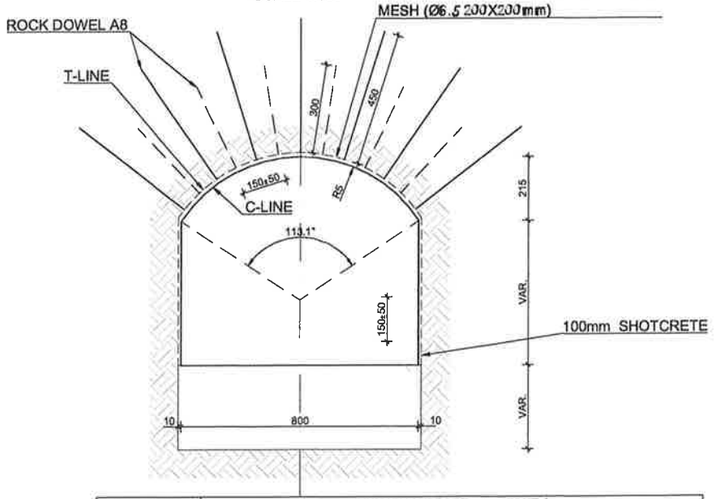
ADIT PROFILE
SCALE 1:500



GENERAL NOTES:
1. LOCAL ADDITIONAL SUPPORT TO BE EVALUATE ON SITE.
2. THE CHOICE OF THE SUPPORT SECTION TYPE OF DESIGN TO BE APPLIED IS BASED ON GEOMECHANICAL CONDITIONS AT TUNNEL FACE DEFINED BY FACE MAPPING. EACH SECTION TYPE HAS A SPECIFIC FIELD OF APPLICATION BASED ON DEFINED GEOMECHANICAL CONDITIONS. THE SUPPORT VARIABILITY INCLUDED IN EACH SUPPORT SECTION TYPE IS MANAGED ON SITE ON THE BASIS OF VISUAL INSPECTION, EXCAVATION BEHAVIOUR AND MONITORING RESULTS BY THE DESIGN REPRESENTATIVE.

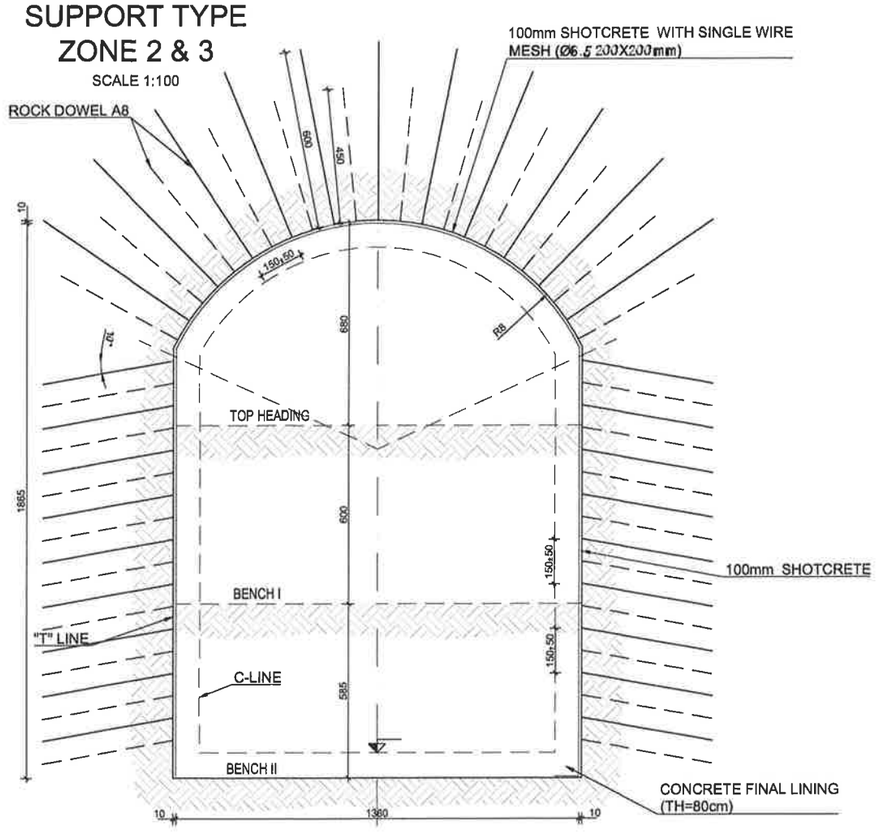


SUPPORT TYPE ZONE 1
SCALE 1:100



EXACAVATION METHOD	PRIMARY SUPPORT TYPE ZONE A Range of application: RMR>40 & Q>0.215
FULL-FACE EXCAVATION	ROUND LENGHT: 1.5±0.50m
	SYSTEMATIC PROBE-HOLE (MIN.OVERLAPPING 10m: FOR EXAMPLE L=60m REPEATED EVERY 50m)
	100mm SHOTCRETE WITH SINGLE WIRE MESH (ϕ6.5 200X200mm) IN THE CROWN AND 100mm SHOTCRETE IN THE SIDEWALLS
	SYSTEMATIC ROCK DOWEL A8 PATTERN 1.5±0.50×1.5±0.50m IN THE CROWN , ROCK DOWEL A8 WITH Fy≥200KN (DIA.25mm MIN), L=3.0m/4.5m

SUPPORT TYPE ZONE 2 & 3
SCALE 1:100



EXACAVATION METHOD	PRIMARY SUPPORT TYPE ZONE B&C Range of application: RMR>40 & Q>0.215
TOP-HEADING & BENCHING EXCAVATION	ROUND LENGHT: 1.5±0.50m
	SYSTEMATIC PROBE-HOLE (MIN.OVERLAPPING 10m: FOR EXAMPLE L=60m REPEATED EVERY 50m)
	100mm SHOTCRETE WITH SINGLE WIRE MESH (ϕ6.5 200X200mm) IN THE CROWN AND 100mm SHOTCRETE IN THE SIDEWALLS
	SYSTEMATIC ROCK DOWEL A8 PATTERN 1.5±0.50×1.5±0.50m IN THE CROWN AND1.5±0.50 ×1.5±0.50m IN THE SIDEWALLS, ROCK DOWEL A8 WITH Fy≥200KN (DIA.25mm MIN), L=4.5-6.0m

Originator

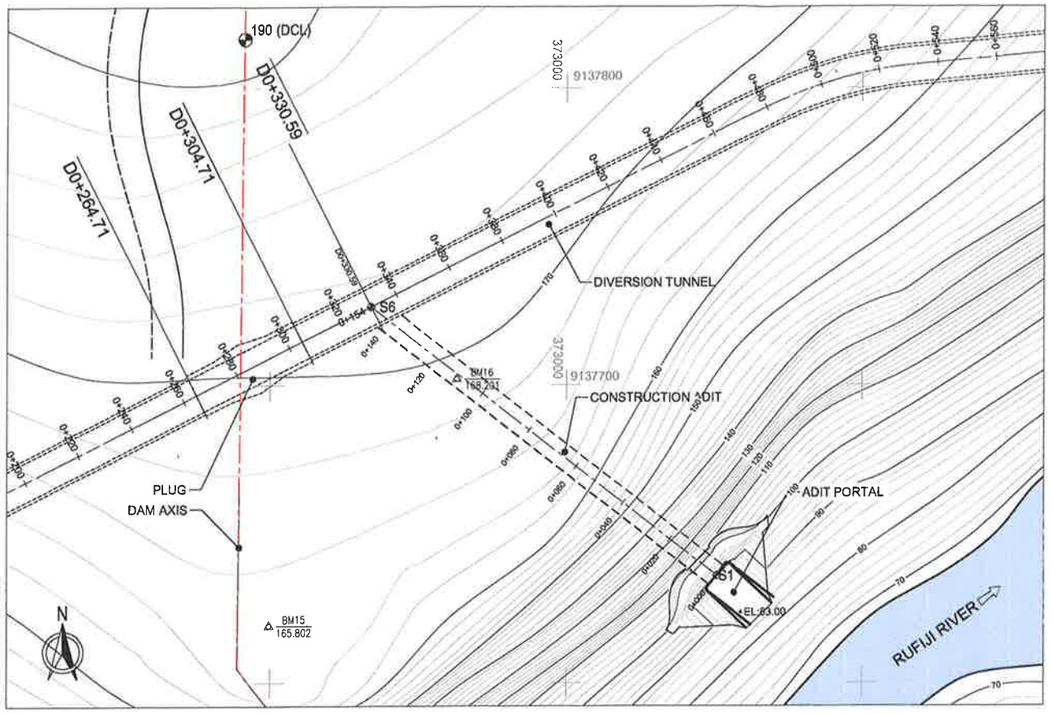
The Arab Contractors — Elsewedy Electric

Title

DIVERSION TUNNEL
Adit and Diversion tunnel intersection
Supports type C1

Detail Design

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Document no. RUF-SHC360-ULX-&CTA010-001001	Rev. 00	PAGE NO. 08



PLAN VIEW

SCALE 1:1000

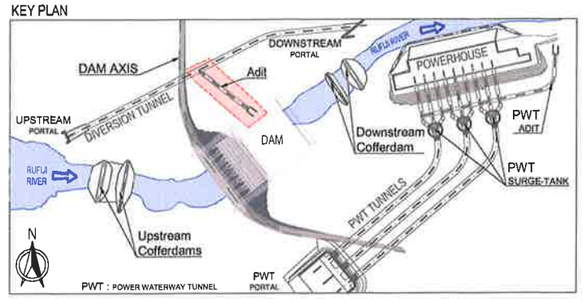
GENERAL NOTES:

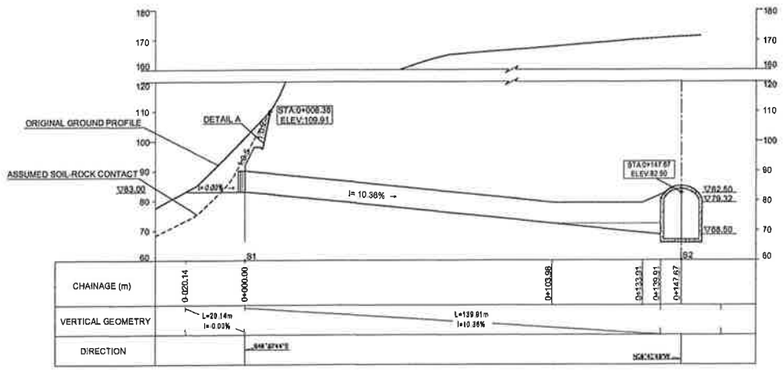
1. FOR ACCESS ROADS PLEASE REFER TO SPECIFIC DRAWINGS.

CONTROL POINTS COORDINATES		
n°	X	Y
S1	373050.7867	9137835.8399
S6	372933.9352	9137726.3237

GRAPHIC SCALE 1:2000 (0, 20, 40, 100m)

KEY PLAN





CONSTRUCTION ADIT
- L-PROFILE

SCALE 1:1000

Originator

The Arab Contractors — Osman Ahmed Osman & Co. — المقاولون العرب — شركة عثمان أحمد عثمان وشركاه

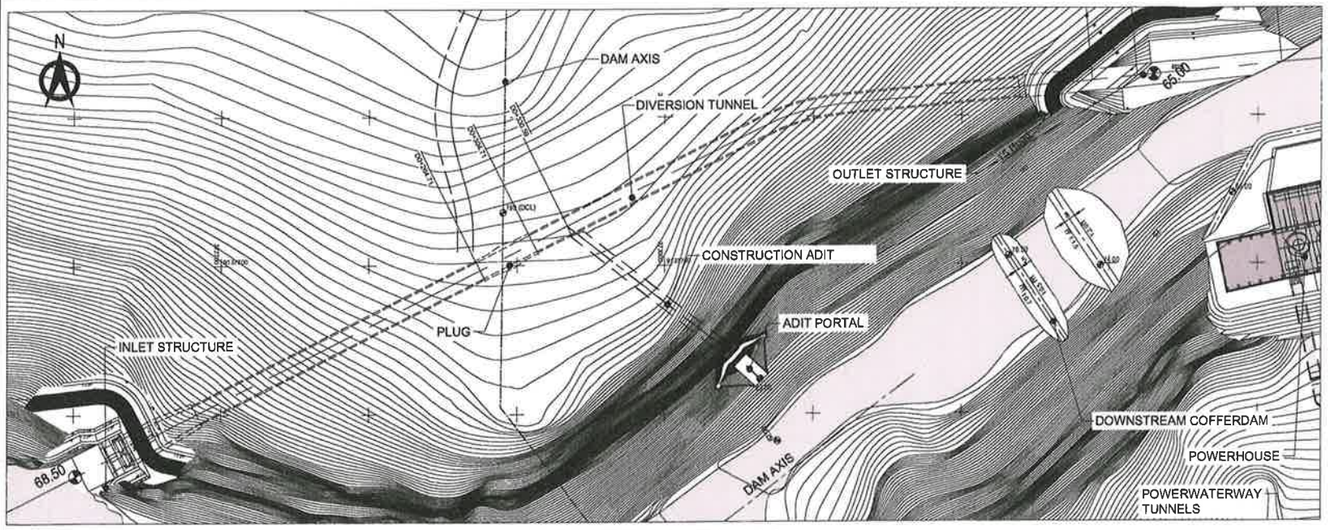
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Title

DIVERSION TUNNEL
Intermediate Adit - Alignament
Plan view and L- Profiles

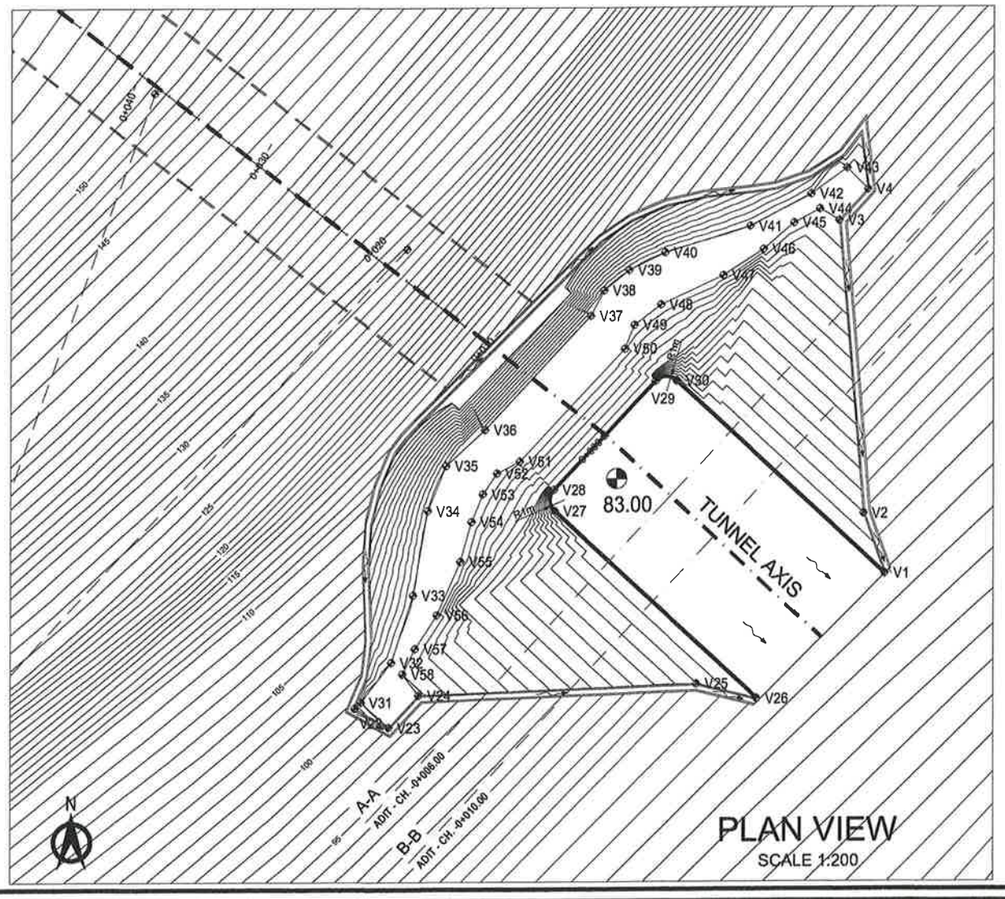
Detail Design

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Document no. RUF-SHC360-ULX-&CTA010-001001	Rev. 00	PAGE NO. 09



GENERAL PLAN

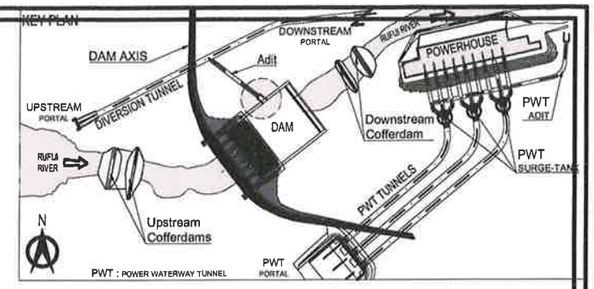
SCALE 1:2000



PLAN VIEW

SCALE 1:200

PORTAL EXCAVATION - SET-OUT COORDINATES			
	n°	X	Y
	V1	373065.7485	9137630.1323
	V2	373064.3101	9137634.1705
	V3	373062.6623	9137653.8708
	V4	373064.5972	9137655.9585
	V22	373029.9957	9137621.1388
	V23	373032.3104	9137619.8559
	V24	373034.3279	9137622.0251
	V25	373053.0281	9137622.7492
	V26	373057.1106	9137621.7344
	V27	373043.5002	9137634.3931
	V28	373043.4517	9137635.8093
	V29	373050.2904	9137643.1034
	V30	373051.7175	9137643.1362
	V31	373030.4155	9137621.5527
	V32	373032.4849	9137624.2350
	V33	373033.9455	9137628.7434
	V34	373034.9191	9137634.4301
	V35	373036.1463	9137637.4457
	V36	373038.7644	9137639.8573
	V37	373045.9481	9137647.5194
	V38	373046.8248	9137649.2197
	V39	373048.5185	9137650.5899
	V40	373050.9231	9137651.7448
	V41	373056.6516	9137653.5031
	V42	373060.7703	9137655.6480
	V43	373063.1842	9137657.3921
	V44	373061.3545	9137654.6341
	V45	373059.6244	9137653.7156
	V46	373057.5666	9137651.9433
	V47	373054.8271	9137650.1912
	V48	373050.6462	9137648.2411
	V49	373048.8793	9137646.8886
	V50	373048.2300	9137645.2871
	V51	373041.1401	9137637.7251
	V52	373039.5663	9137636.9240
	V53	373038.6276	9137635.5239
	V54	373037.8717	9137633.8590
	V55	373037.1175	9137631.0022
	V56	373035.5321	9137627.4108
	V57	373034.0696	9137625.1655
	V58	373033.2377	9137623.4631



GENERAL NOTES:

1. FOR ACCESS ROADS PLEASE REFER TO SPECIFIC DRAWINGS.
2. SOIL ROCK CONTACT SURFACE IS ASSUMED ACCORDING TO AVAILABLE DATA. PORTAL EXCAVATION TO BE ADJUSTED ACCORDING TO REAL CONTACT SURFACE ENCOUNTERED ON SITE.
3. SCALING ON EXISTING SLOPES ABOVE PORTAL EXCAVATION MUST BE DONE AS FIRST ACTION BEFORE SLOPE EXCAVATION.
4. IF UNSTABLE ROCK WEDGES NOT COMPRISED IN ROCK DOWEL GRID ARE IDENTIFIED DURING VISUAL INSPECTIONS OF CUT SLOPES, THEY MUST BE SECURED WITH A ROCK DOWEL OR REMOVED BY SCALING.
5. AN ACCURATE CLEANING OF SUPERFICIAL LOOSE MATERIAL SHALL BE DONE BEFORE SOIL SLOPE EXCAVATION. THIS MUST BE DONE IN ORDER TO CUT SLOPES IN MORE COHESIVE MATERIAL.
6. LOSE SOIL LAYING IN UNSTABLE EQUILIBRIUM ON BEDROCK SHALL BE REMOVED OR LYING DOWN WITH A GRADIENT 3H:2V.
7. AN ACCURATE CLEANING OF SUPERFICIAL LOOSE MATERIAL AT THE PORTAL AREA SHALL BE DONE BEFORE SLOPE EXCAVATION. ACCURATE CHECK OF GEOLOGICAL AND GEOMECHANICAL DESIGN ASSUMPTIONS WILL BE DONE.
8. LENGTH, ORIENTATION AND PATTERN OF SLOPE PROTECTIONS AND DRAINAGE PIPES CAN BE OPTIMIZED ON SITE ACCORDING TO GEOLOGICAL / GEOSTRUCTURAL / HYDROGEOLOGICAL CONDITIONS ENCOUNTERED ON SITE.
9. WIRE MESH SHEETS FOR SOIL SLOPES SHALL OVERLAP FOR A MINIMUM LENGTH OF TWO TIMES THE MESH GRID SIZE. EXTRA WIRE MESH SHALL BE INSTALLED AT CORNERS AND EDGES, TO PROVIDE FULL CONTINUITY OF SUPPORT.
10. MATERIAL PROPERTIES SHALL COMPLY WITH THE REQUIREMENTS INDICATED IN TECHNICAL SPECIFICATIONS.

0 20 40 100cm
GRAPHIC SCALE 1:20

0 2 4 10m
GRAPHIC SCALE 1:200

0 20 40 100m
GRAPHIC SCALE 1:2000

Originator

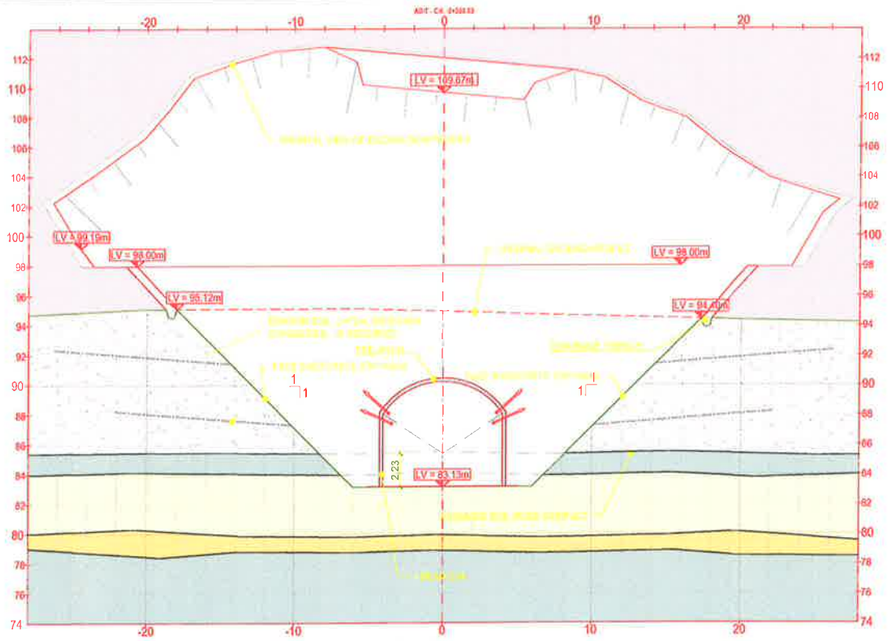
The Arab Contractors — Elsewedy Electric

Title

DIVERSION TUNNEL
Intermediate Adit - Portal Excavation
Plan view and Set Out Coordinates

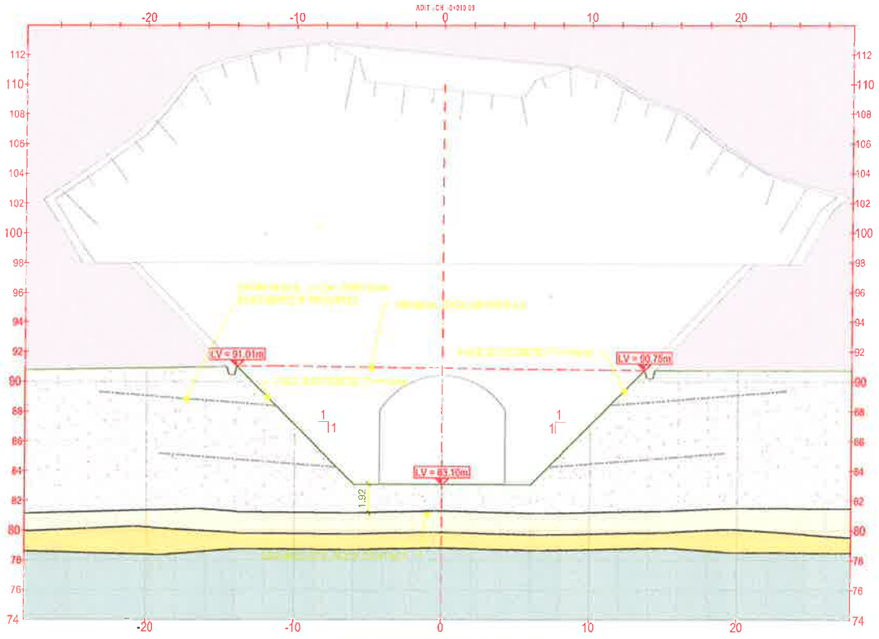
Detail Design

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Document no. RUF-SHC360-ULX-&CTA010-001001	Rev. 00	PAGE NO. 10



SECTION A-A

SCALE 1:200



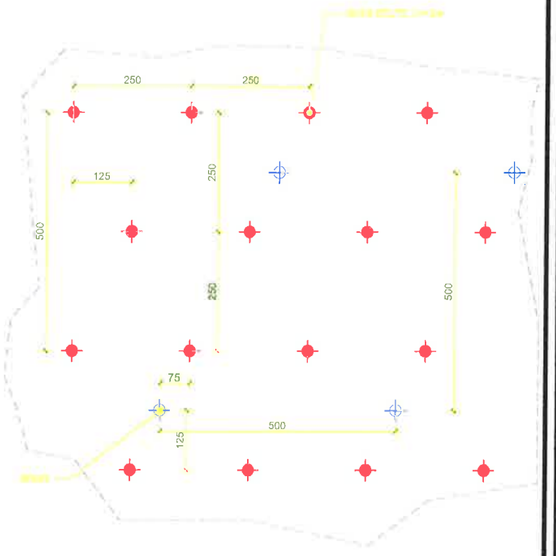
SECTION B-B

SCALE 1:200

MATERIALS:

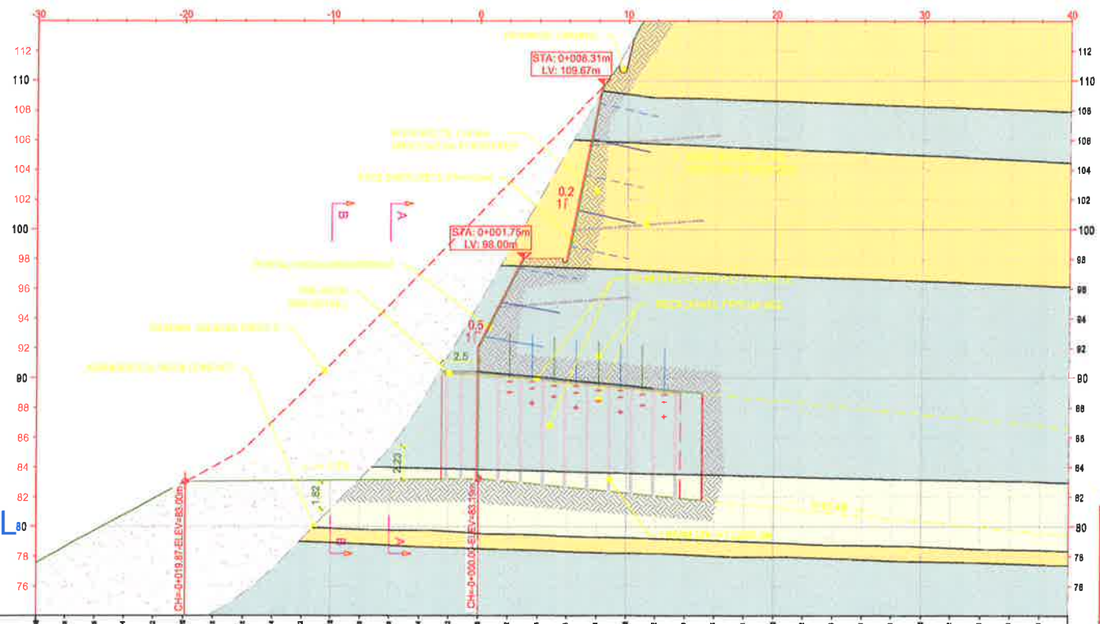
SLOPE PROTECTIONS:

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- [illegible]
- [illegible]
- [illegible]



DOWEL DISTRIBUTION DETAIL

SCALE 1:50



ADIT PORTAL L
PROFILE

SCALE 1:200

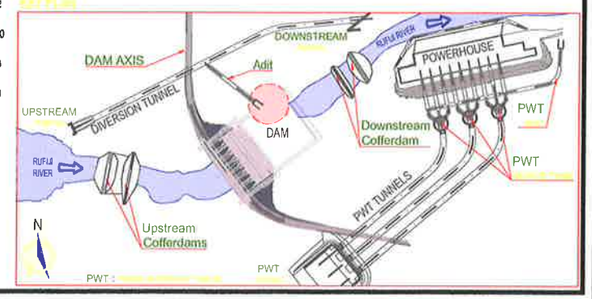
CHAINAGE (m)	
EXISTING GROUND LEVEL (m)	
INVERT OF TUNNEL (m)	
VERTICAL GEOMETRY	
OVERBURDEN (m)	

GRAPHIC SCALE 1:5

GRAPHIC SCALE 1:50

GRAPHIC SCALE 1:20

GRAPHIC SCALE 1:200



Originator

The Arab Contractors — Osman Ahmed Osman & Co.

ELSEWEDY ELECTRIC

Title

DIVERSION TUNNEL

Intermediate Adit - Portal Excavation

Cross Sections and Details

Detail Design

Type: BLACK	Scale: As Shown	Size: A3
Document no. RUF-SHC360-ULX-&CTA010-001001	Rev. 00	PAGE NO. 11

ATTACHMENT # 02
ELECTRIC AND WATER SUPPLY SYSTEMS

Electric and Water Supply System

1. Electric

Description	Input	Remarks
Lights in the Tunnel， Water Pumping	400V 50Hz 3 Phase Power System	
Excavation (Jumbo Drill, Shotcrete Machine)	400V 50Hz 3 Phase Power System	
Concrete pouring (Concrete pump, Vibrator, etc)	400V 50Hz 3 Phase Power System	

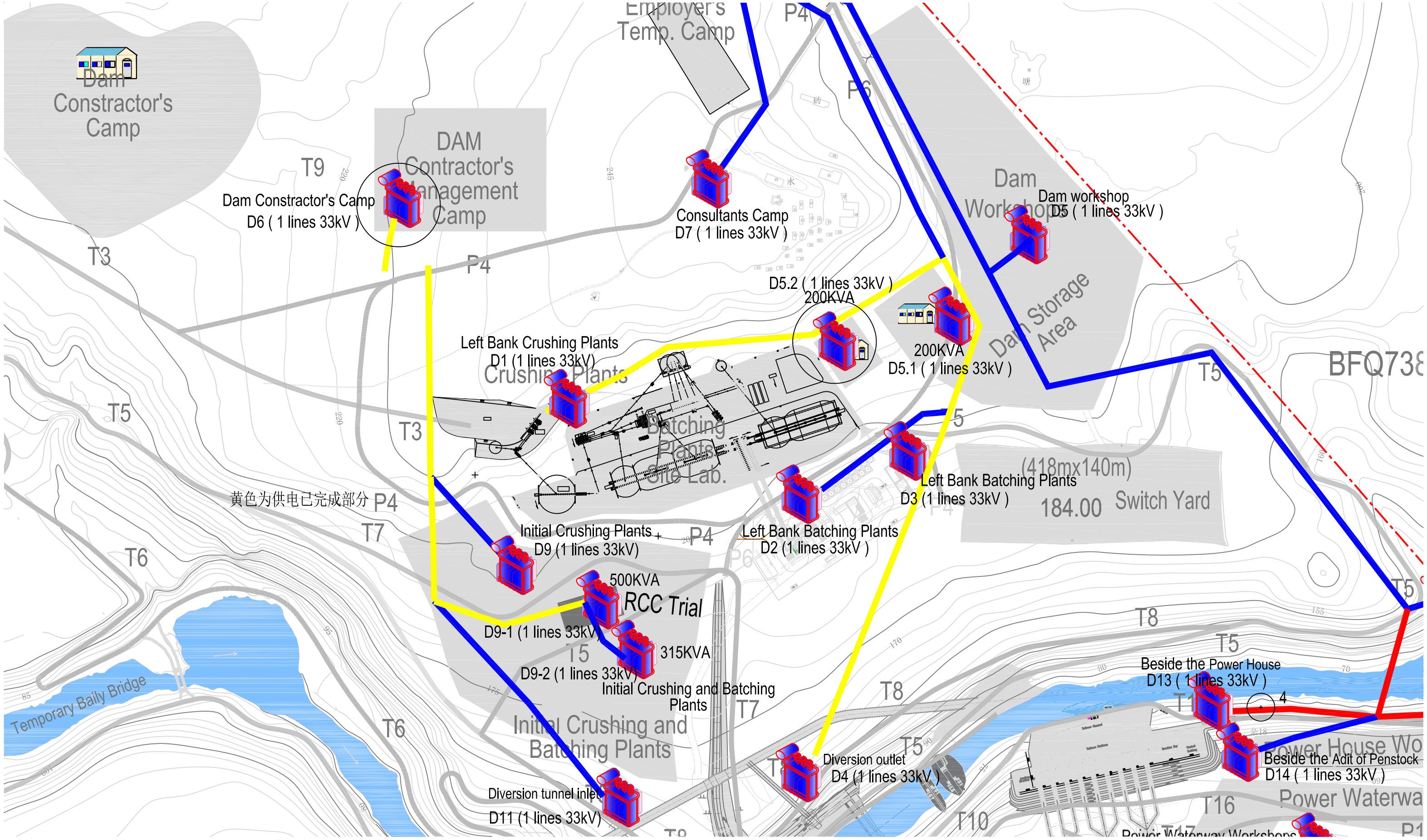
2. Water Supply

Description	Input	Remarks
Excavation (jumbo Drill, Shotcrete Machine)	Pump (7.5 hp)	
Concrete watering protect	Pump (7.5 hp)	

Water Supply Plan For The Diversion Tunnel

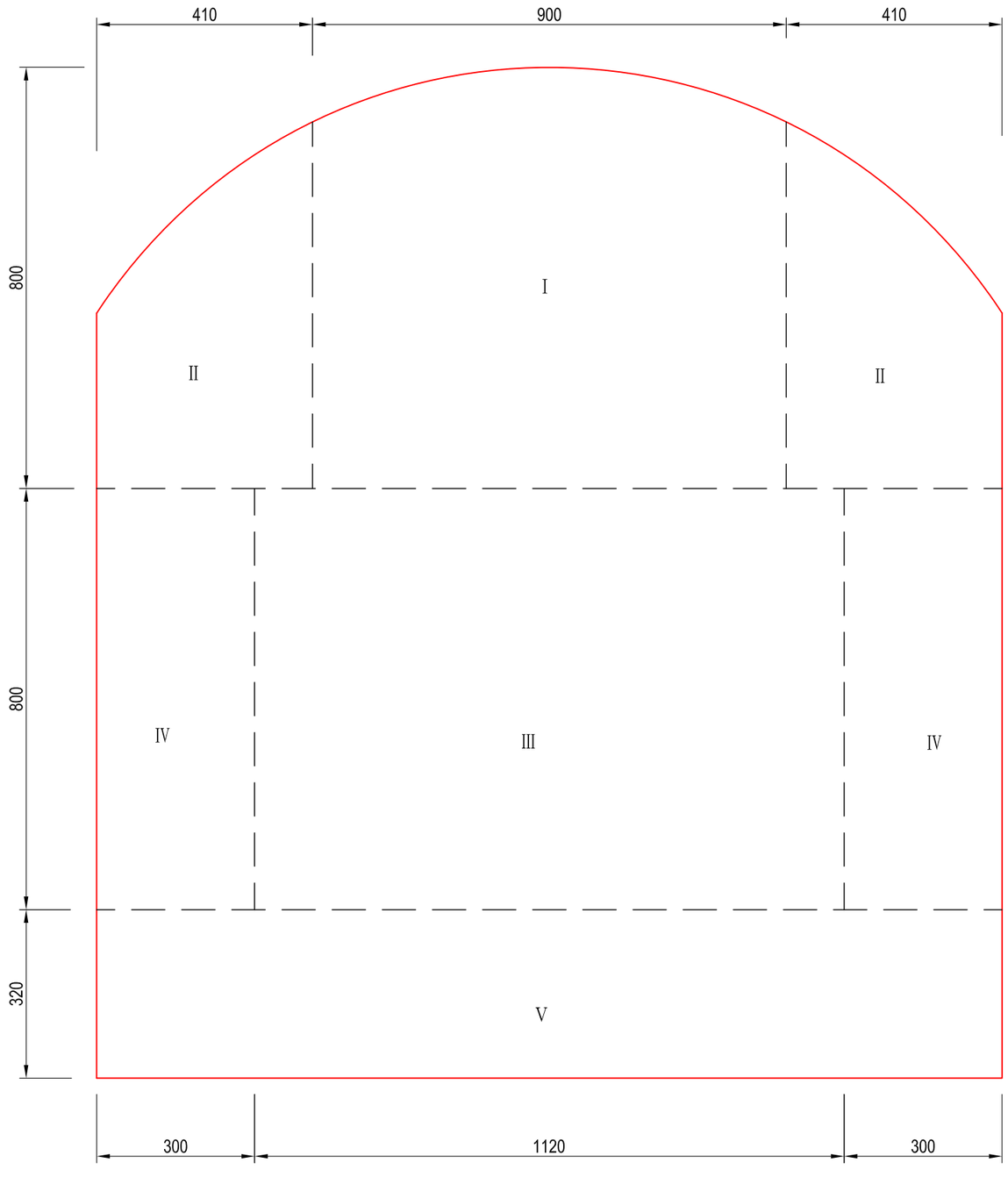
Dam Constractor's Camp
Employer's Temp. Camp
DAM Contractor's Management Camp
Dam Workshops
Dam Storage Area
Existing WATER TANK 20m³
WATER TANK 1 300m³
Secondary Pumping Station
WATER TANK2 4000m³
Crushing Plants
Batching Plants
Site Lab.
(418mx140m) 184.00 Switch Yard
W4 Water Supply Node
RCC Trial
Initial Crushing and Batching Plants
INITIAL WATER SUPPLY PUMP STATION 1 20m³/h
Temporary Baily Bridge
黄色为供水完成部分
PUMP STATION 2
LEFT BANK PUMP STATION 800m³/h
RIGHT BANK PUMP STATION 480m³/h
PUMP STATION 3
Water Supply Node W9
Power House Workshops
Power Waterway Workshops
Water Supply Node W7
Power Waterway Construction Camp
Power Waterway Storage Area
Power House Storage Area
Power House Construction Camp
Water Supply Node W6
P2 Water Supply Node W10
Water Supply Node W11
WATER TANK 4 2200m³
Crushing & Batching Plants Site Lab.
BFQ737
BFQ738
WL1
WL2
WL3
WL4
WL6
WL7
WL8
WL9
WL10
WL14
WL15
WL16
WL17
WL18
WL19
DN80
DN100
DN125
DN150
DN200
DN300
DN400
DN500
P1
P2
P4
P5
P6
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12-1
T12-2
T13
T14
T15
T16
T17
T18

Power Supply Plan For The Diversion Tunnel



ATTACHMENT # 03
BLASTING PATTERN

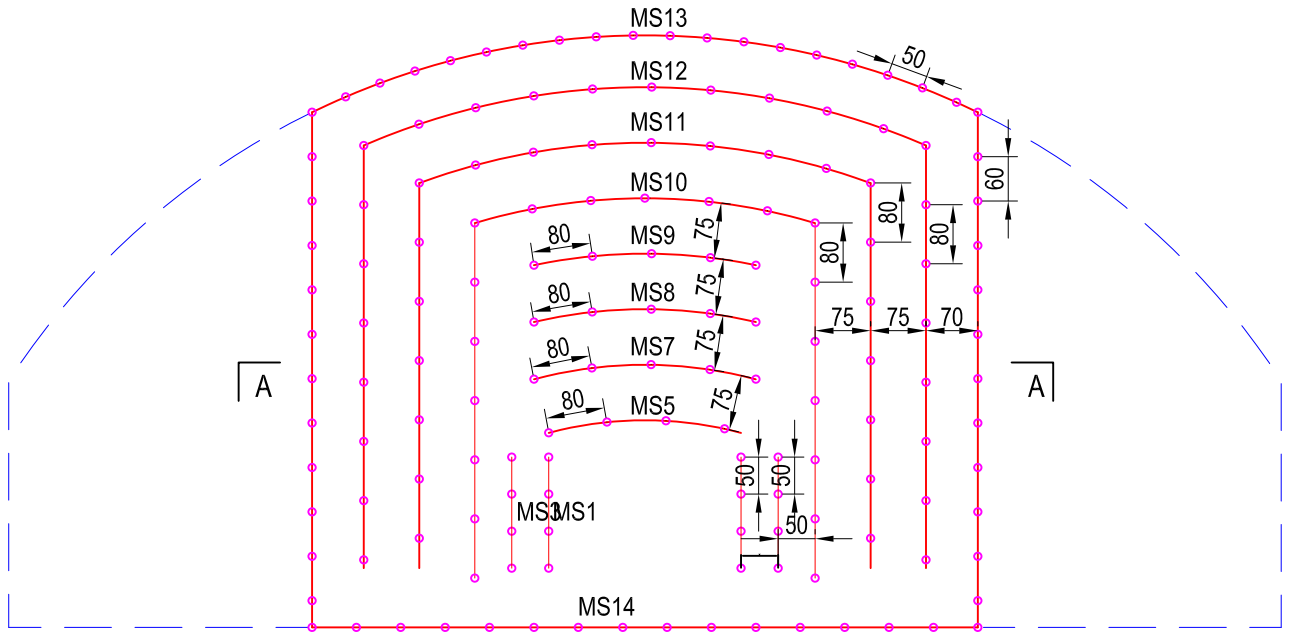
Blasting Excavation of Diversion Tunnel（1/4）



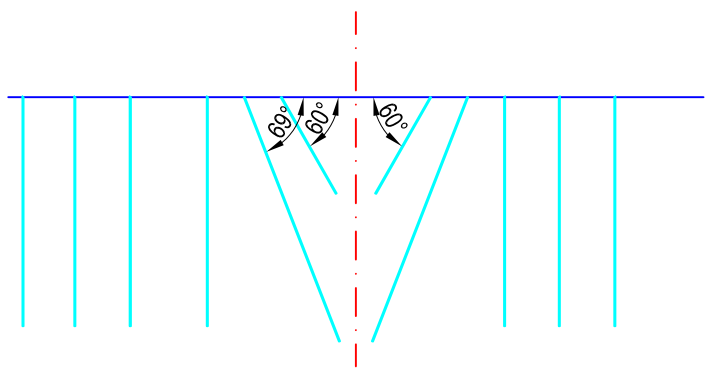
Notes:：
1.All dimensions are in centimeters.
2.The tunnel is zoned Ⅰ, Ⅱ, Ⅲ, Ⅳ and Ⅴ and excavated in five steps, or excavated in staggered flow between zones according to surrounding rock conditions.

BIDDER: XXXX LTD.		PROJECT: Construction of Rufiji Hydropower Project at Stiegler's Gorge along the Rufiji River	
APPROVED		TITLE: Excavation of Diversion Tunnel（1/4）	
CHECKED			
DESIGNED		SCALE: AS SHOWN	REV:
		DRAWING No.: PHP-BD-C1-08-1	

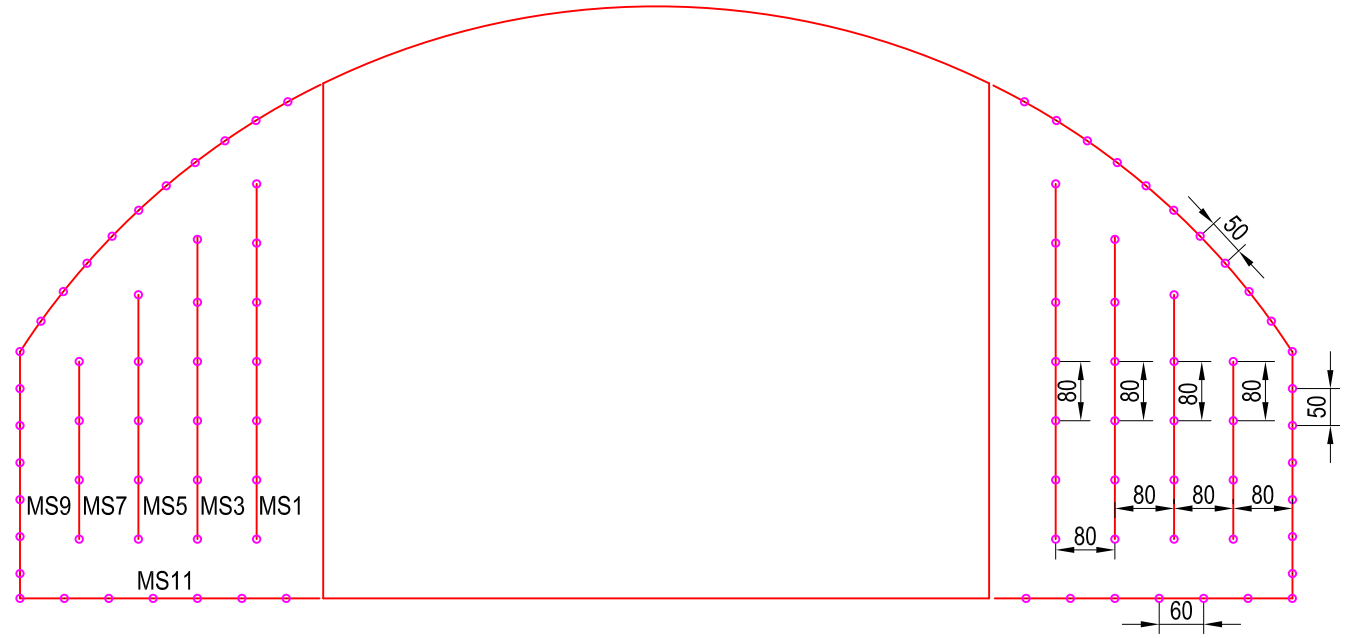
Blasting Excavation of Diversion Tunnel（2/4）



Zone I Blasting and Excavation



Section A-A



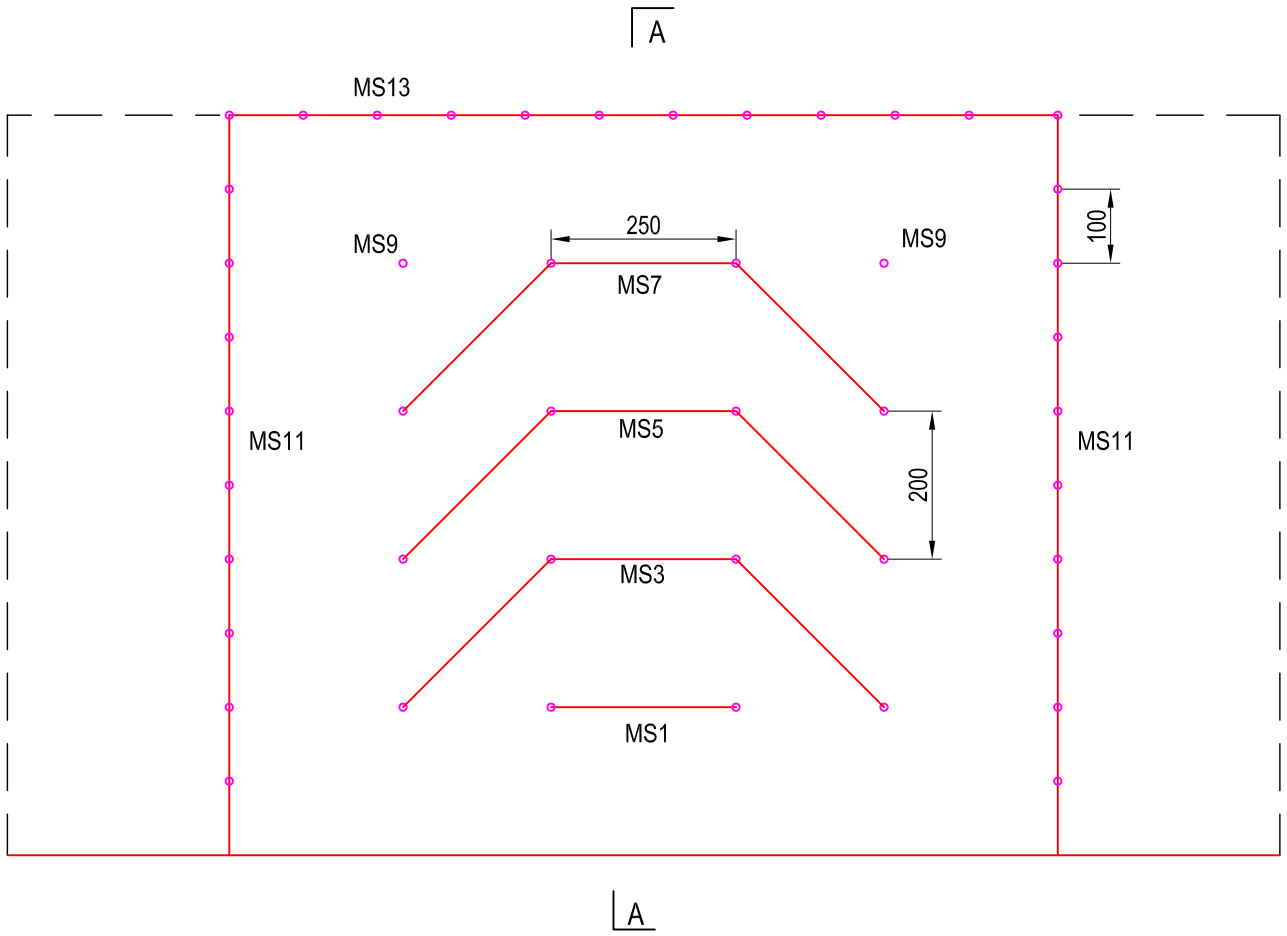
Zone II Blasting and Excavation

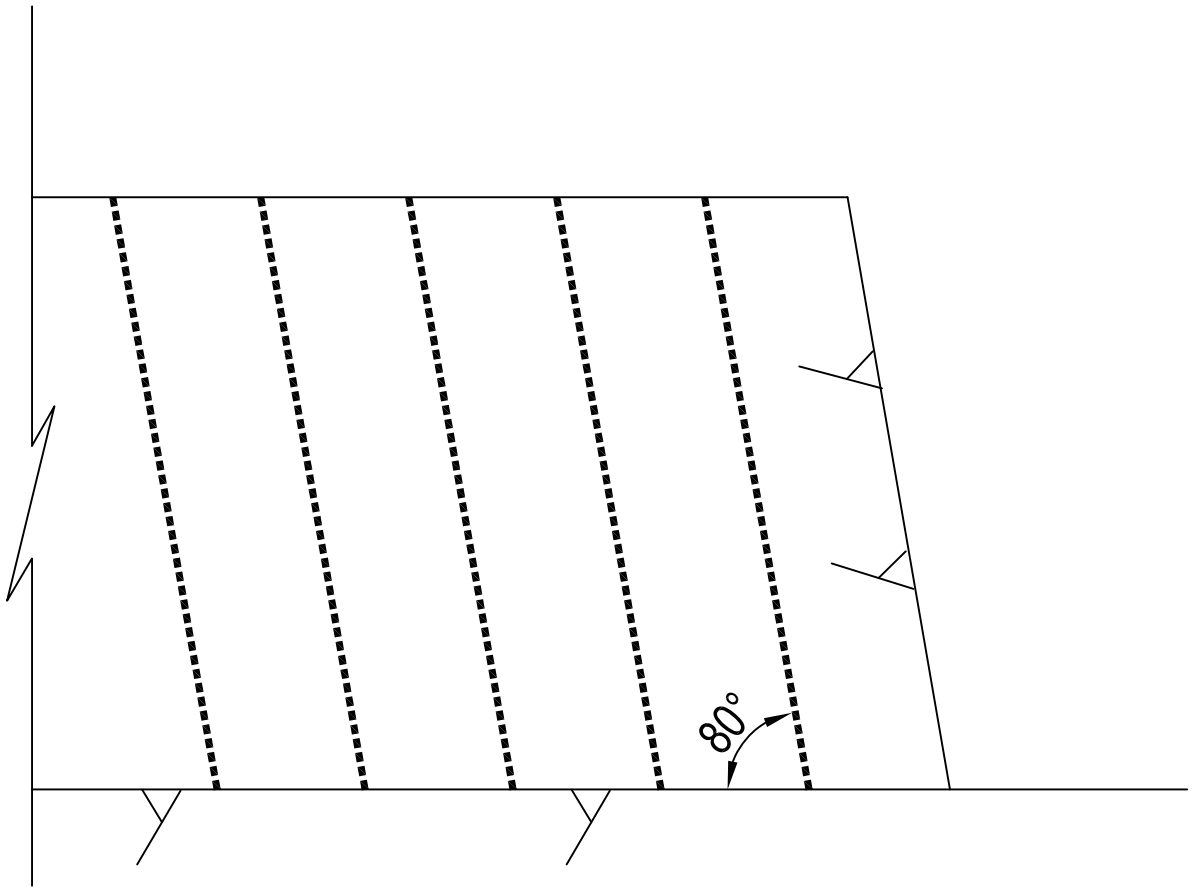
Zone	Type of Hole	Bore Dia.（mm）	Number of Holes（No）	Row Spacing（cm）	Hole Depth（m）	Unit Charging Qty.（g/m）	Hole Charging Qty.（kg）	Average Charge（kg/m^3）	Total Charging（kg）
I	Cut hole	46	16		3.5		2.50	1.40	289.59
	Main blasting hole	46	102	80×75	3.0		2.37		
	Smooth blasting hole	46	20	50	3.2	150	0.42		
	Smooth blasting hole	46	38	60	3.2	180	0.50		
II	Main blasting hole	46	2×22	80×80	3.0		1.1	0.56	75.52
	Smooth blasting hole	46	2×18	47	3.2	150	0.42		
	Smooth blasting hole	46	2×12	60	3.2	180	0.50		

Notes：
1.All dimensions are in centimeters.
2.Smooth blasting is applied in the perimeter and non-electric millisecond detonator network is adopted. Wedge cut is adopted in zone I excavation.
3. Explosive is charged alternately in bores and bar type emulsion explosive is used.
4. Blasting parameters is adjusted based on actual site conditions.

BIDDER: XXXX LTD.		PROJECT: Construction of Rufiji Hydropower Project at Stiegler's Gorge along the Rufiji River	
APPROVED		TITLE: Diversion Tunnel Blasting Excavation（2/4）	
CHECKED			
DESIGNED		SCALE: AS SHOWN	REV:
		DRAWING No.: PHP-BD-C1-08-2	

Blasting Excavation of Diversion Tunnel（3/4）





Section A-A

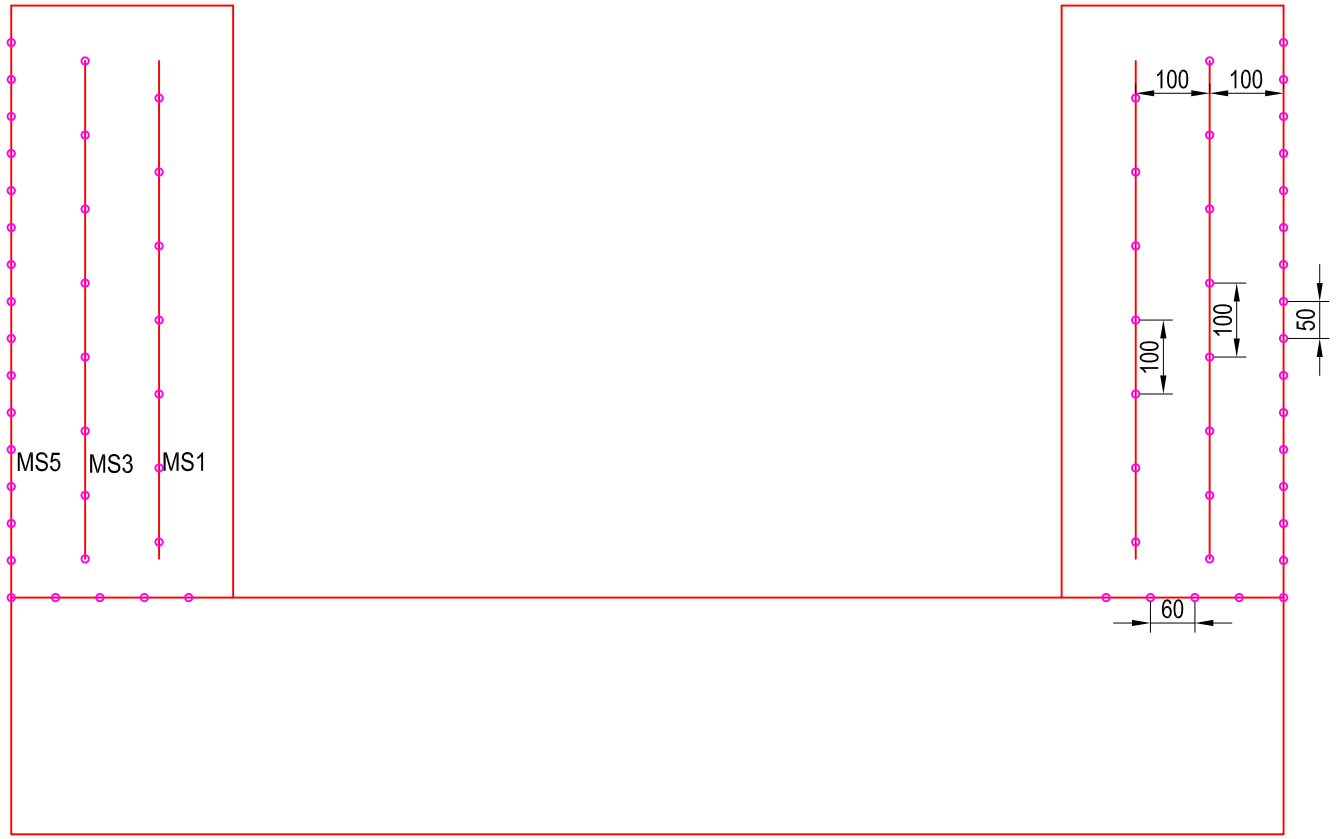
Zone III Blasting and Excavation

Zone	Type of Hole	Bore Dia. （mm）	Number of Holes （No）	Row Spacing （cm）	Hole Depth （m）	Unit Charging Qty. （g/m）	Hole Charging Qty. （kg）	Average Charge （kg/m^3）	Total Charging （kg）
III	Blasting hole	76	16	2.5×2.0	8.0		17.15	0.40	358.4
	Hole of smooth blasting	76	30	60	8.5	350	2.8		

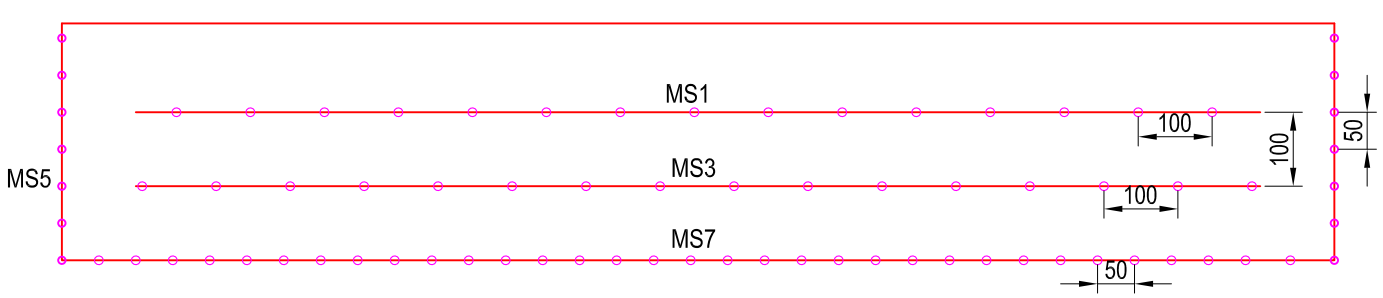
Notes：
1.All dimensions are in centimeters.
2.Smooth blasting is applied in the perimeter and non electric millisecond detonator network is used.
Wedge cut is adopted in zone I excavation.
3. Explosive is charged alternately in bores and bar type emulsion explosive is used.
4. Blasting parameters is adjusted based on actual site conditions.

BIDDER: XXXX LTD.		PROJECT: Construction of Rufiji Hydropower Project at Stiegler's Gorge along the Rufiji River
APPROVED	TITLE: Diversion Tunnel Blasting Excavation（3/4）	
CHECKED		
DESIGNED	SCALE: AS SHOWN	REV:
	DRAWING No.: PHP-BD-C1-08-3	

Blasting Excavation of Diversion Tunnel（4/4）



Zone IV Blasting and Excavation



Zone V Blasting and Excavation

Blasting Schedule

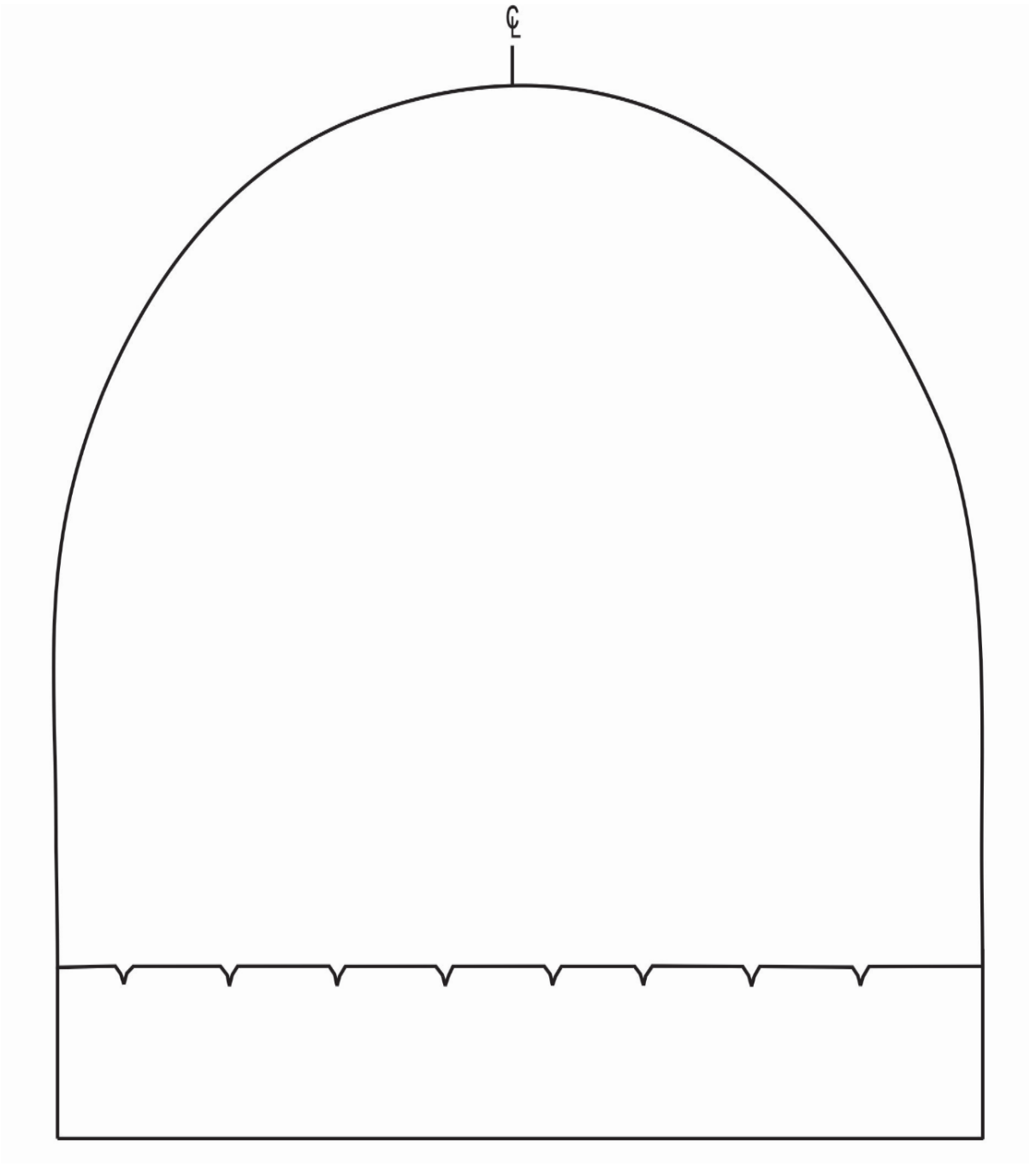
Zone	Type of Hole	Bore Dia. （mm）	Number of holes （No）	Row Spacing （cm）	Hole Depth （m）	Line Charging Qty （g/m）	Hole Charging （kg）	Average Charging （kg/m^3）	Total Charging （kg）
IV	Main blasting hole	46	2×15	100x100	4.0		1.93	0.42	80.64
	Main blasting hole	46	2×20	50	4.2	150	0.57		
V	Main blasting hole	46	31	100x100	4.0		3.10	0.59	129.89
	Main blasting hole	46	59	47	4.2	150	0.57		

Notes：
1. All dimensions are in centimeters.
2.Footage cycle is 10m.
3. Smooth blasting is applied in the perimeter and non electric millisecond detonator network is used. Wedge cut is adopted in zone I excavation.
4. Explosive is charged alternately in bores and bar type emulsion explosive is used.
5. Blasting parameters is adjusted based on actual site conditions.

BIDDER: XXXX LTD.		PROJECT: Construction of Rufiji Hydropower Project at Stiegler's Gorge along the Rufiji River	
APPROVED		TITLE: Diversion Tunnel Blasting Excavation（4/4）	
CHECKED			
DESIGNED		SCALE: AS SHOWN	REV:
		DRAWING No.: PHP-BD-C1-08-4	

ATTACHMENT # 04
FACE MAPPING PERFORMA

Tunnel Face Mapping Note						
Project Name	2115 MW Rufiji HPP	Geologist/ Geological Engineer	Contractor	Subcontractor	EC Geologist	
Location		Date		Time		
Station			Rock Name			



Description:

Project Name			2115 MW Rufiji Hydropower Project (Diversion Tunnel)									
Location			Station					Date			Time	
Geologist								Rock Name				
1- Strenght of intact Rock Material								(D) Roughness				
PLI (Is_{50})	>10 MPA	4-10MPA	2-4MPA	1-2MPA	UCS Only			Division	V.Rough	Rough	S.Rough	Smooth	Slickenside
UCS	>250	100-250	50-100	25-50	5-25	1-5	<1	J1					
RMR value	15	12	7	4	2	1	0	J2					
2- R.Q.D								J3					
RQD(%)	90-100	75-90	50-75	25-50	<25			J4					
RMR value	20	17	13	8	3			J5					
3- Spacing of Discontinutinuities/Joints								RMR value	6	5	3	1	0
Joint sets	>2m	0.6-2m	200-600mm	60-200mm	<60mm			(E) Weathering					
J1								Division	Fresh	S.Weathered	M.Weathered	H.Weathered	Decomposed
J2								J1					
J3								J2					
J4								J3					
J5								J4					
RMR value	20	15	10	8	5			J5					
4- Condition of Discontinuities/Joints								RMR value	6	5	3	1	0
(A) Persistence								RMR Rating (A+B+C+D+E)=					
Division	<1m	1-3m	3-10m	10-20m	>20m			5- Ground Water Ratio					
J1								Division	Dry	Damp	Wet	Dripping	Flowing
J2								RMR value`	15	10	7	4	0
J3								6- Rating Adjustment for Discontinuity Orientations					
J4								Classification		Dip	Strike/Dip Direction		RMR Rating
J5								J1					
RMR value	6	4	2	1	0			J2					
(B) Apperture/Seperation								J3					
Division	None	<0.1mm	0.1-1mm	1-5mm	>5mm			J4					
J1								J5					
J2								Strike And Dip orientation in Tunnelling					
J3								Strike ⊥ to Tunnel Axis			Strike // to Tunnel Axis		Irrespective of strike
J4								Drive with dip		Drive against dip			
J5								Dip 45-90°	Dip 20-45°	Dip 45-90°	Dip 20-45°	Dip-45-90°	Dip 20-45°	Dip 0-20°
RMR value	6	5	4	1	0			V.favourable	Favourable	Fair	Un-Favourable	Very Unfavourable	Fair	Fair
(C) Infilling(Gouge)								0	-2	-5	-10	-12	-5	-5
Division	None	Hard Filling < 5mm	Hard Filling > 5mm	Soft Filling < 5mm	Soft Filling > 5mm			RMR Score						
J1														
J2														
J3														
J4														
J5								Rock Type				Remarks		
RMR value	6	4	2	2	0									

ATTACHMENT # 05
CHECKLIST FOR TUNNEL STEEL SUPPORT

Checklist for Tunnel Steel Support & Shotcrete

RFI No.		Inspection Date			
Structure	Diversion Tunnel	Station			
No.	Check Point	Inspection			Note
		SubContractor Site Engineer/ Surveyor	Contractor Site Engineer/ Surveyor	Contractor QA/QC Engineer/ Inspector	
1	Has the Lot of steel been tested and approved?				
2	Are the members of Lattice girder/H-Beam handled and installed properly (so that curvature and shape is not disturbed)?				
3	Are bottom ends of Lattice girder/H-Beam placed strongly and closely to ground surface?				
4	Has the specified cover been provided?				
5	Are the no of spacers as per drawing and Nut/ bolt properly tied?				
6	Has emergency reinforcement plan been made and materials are stocked?				
Placement of Shotcrete					
7	Has shotcrete mix design been approved in accordance with specification?				
8	Has measures been taken so that the thickness of shotcrete may be achieved?				
9	Have all the depressions of excavated rock surface been closed by shotcrete layers?				
10	Has the wire mesh been employed and installed properly i.e. over lap and fixing?				

ATTACHMENT # 06
EXPLOSIVITY /GAS MONITORING SHEET & CONFINED SPACE ENTRY/EXIT

Attached to PTW No.: ……

EXPLOSIVITY / GAS MONITORING SHEET

Subsequent air quality / gas / explosive atmosphere tests before entry by competent person

GAS DETECTOR / METER IDENTIFICATION:

Type of test	Limit Value	Result	Date	Time	Name & Sign
Explosive atmosphere	10% lower explosive limit (LEL)				
Carbon monoxide (CO)	50 ppm max.				
Oxygen (O_2)	19.5 – 21%				
Hydrogen Sulphide (H_2S)	10 ppm max.				

GAS DETECTOR / METER IDENTIFICATION:

Type of test	Limit Value	Result	Date	Time	Name & Sign
Explosive atmosphere	10% lower explosive limit (LEL)				
Carbon monoxide (CO)	50 ppm max.				
Oxygen (O_2)	19.5 – 21%				
Hydrogen Sulphide (H_2S)	10 ppm max.				

GAS DETECTOR / METER IDENTIFICATION:

Type of test	Limit Value	Result	Date	Time	Name & Sign
Explosive atmosphere	10% lower explosive limit (LEL)				
Carbon monoxide (CO)	50 ppm max.				
Oxygen (O_2)	19.5 – 21%				
Hydrogen sulphide (H_2S)	10 ppm max.				

GAS DETECTOR / METER IDENTIFICATION:

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GAS DETECTOR / METER IDENTIFICATION:

Type of test	Limit Value	Result	Date	Time	Name & Sign
Explosive atmosphere	10% lower explosive limit (LEL)				
Carbon monoxide (CO)	50 ppm max.				
Oxygen (O_2)	19.5 – 21%				
Hydrogen sulphide (H_2S)	10 ppm max.				

Attached to PTW No.: …………………………

Confined Space Entry/Exit Log

Date	Name (Block Letters)	Time in	Supervisor signature	Time out	Supervisor signature

ATTACHMENT # 07
EXPLOSIVE AND DETONATOR REGISTER FORMAT

Explosives & Detonator Maintenance Report

Date	Dairy Opening stock	Customer Name	Location	Qty Received	Qty Issued	Qty Balance	Signature	Remark

Explosives & Detonators Maintenance Report

Explosive & Detonators Maintenance Report												
Date	Withdrawal (Q'ty)		Subcontractor	Contractor	Used (Q'ty)		Subcontractor	Contractor	Return (Q'ty)		Subcontractor	Contractor
	Detonators (ea)	Explosive (Kg)			Detonators (ea)	Explosive (Kg)			Detonators (ea)	Explosive (Kg)		

Instruction:

- Misfired explosives and detonators should be returned to Persons responsible.
- Misfired explosives and detonators will be used for next blasting.
- Misfired explosives and detonators should be kept separately.
- Explosives and detonators should be away from the electronic equipment and electronic stove.
- Explosives and detonators should be managed most carefully.

ATTACHMENT # 08
RISK ASSESSMENT PLAN

The Arab Contractors
Osman Ahmed Osman & Co.
المقاولون العرب
عثمان أحمد عثمان وشركاه

ELSEWEDY ELECTRIC

RUFIJI HYDROPOWER PROJECT

PROJECT SPECIFIC PROCEDURE

JV/HSE-SI01

METHOD STATEMENT & RISK ASSESSMENT
SITE INSTRUCTION

0	30 Oct. 2018	HSE Coordinator	Sr. HSE Manager	Project Managers	JV Director
Rev	Issue Date	Prepared	Reviewed	Reviewed	Approved

REVISION RECORD SHEET

Note



i. Revisions after Rev. 0 are denoted by a vertical line in the left hand margin against the revised text, with the revision number displayed next to the revision line as shown by the example on the left.

Rev. No.	Date	Description of Revision	Prepared by	Reviewed by	Reviewed by	Approved by
00	30 Oct. 2018	– Issued for Approval. – Issued for distribution and implementation	AF&AT	SB	WA - MH	AO

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1.2 Scope 4
1.3 Abbreviations 4
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2.2 Risk/Impact Assessment Process 5
2.2.1 Hazard Identification 5
2.2.2 Risk Evaluation 7
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4.0 PREPARATION OF MSRA 9
5.0 SUBMISSION AND REVIEW OF MSRA 9
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6.3 Att.03 MSRA Cover Page 10
6.4 Att.04 MSRA Log 10

1.0 INTRODUCTION

1.1 Objectives

- This procedures and instructions are established and maintained to insure that all HSE Risks, Aspects, Hazards and Impacts are identified, Assessed and to ensure the existence of sufficient and suitable control measures are in place.
- To ensure that the risks are controlled As Low As Reasonably Practicable.
- To inform the Contractor / subcontractors of the Method Statement / Risk Assessment procedure.

1.2 Scope

- This procedure, instructions to be applied for all work activities of Contractor / subcontractors. All working activities shall be conducted in accordance with approved MSRA.
- This Site Instruction has immediate effect until the end of the Project. It may be revised by the contractor based on site requirements.

1.3 Abbreviations

HSE	–	Environment, Health and Safety
SDS	–	Safety Data Sheet
MS/RA	–	Method Statement / Risk Assessment
PTW	–	Permit to Work
Contract(	–	JV ARAB CONTRACTORS & ELSEWEDY ELECTRIC

1.4 Definitions

Hazard:	–	Any situation that has the potential to cause harm to the health and safety of personnel and/or to the environment and/or material resources.
Risk:	–	Is the likelihood of harm occurring as a result of a hazard and takes into account the probable severity of the consequences should harm occur.
Method Statement:	–	is a detailed description of any given work activity, work procedure and/or sequence of operations that, in conjunction with a Risk Assessment, fully assesses any risks involved and details the sub-sequent HSE measures that will be implemented to control the risks.
Risk Assessment:	–	Identifies hazards, assesses the risks and the severity of potential consequences and determines control measures to eliminate, avoid, reduce or otherwise manage those risks to prevent harm.

1.5 References

- Project HSE Plan
- THE OCCUPATIONAL HEALTH AND SAFETY ACT, 2003.
- THE EMPLOYMENT AND LABOUR RELATIONS (GENERAL) REGULATIONS, 2017
- ISO45001, ISO 14001 and SA 8000 Standers
- ELSEWEDY ELECTRIC HSE Management System

1.6 MS/RA Procedure

- This procedure combines the method statement and risk assessment forms into one document, designed to ensure that Contractor / Subcontractor to meet their HSE responsibilities in the workplace, and is based on the general principles of risk prevention, as follows:

i. Identify hazards and subsequent risks
ii. Eliminate or avoid risks
iii. Assess and control risks when they cannot be eliminated or avoided
iv. Collective protection has priority over individual protection
v. Use work methods and equipment adapted to task and the risk
vi. Consider technical evolutions of the work
vii. Plan prevention

viii. Record findings and control measures
ix. Inform and train employees about the risks and the control measures
x. Review the risk assessment regularly and update when necessary

2.0 PROCEDURES

2.1 General

– Management of Risk is a continuous process and the cornerstone of all the HSE elements. The subcontractor shall regularly identify the Hazards and analyze the Risks for his own and third party operatives in the surrounding area associated with his activities. The subcontractor shall take appropriate action to manage the Risks during construction phase and consequently prevent or reduce the impact of potential accidents or incidents.
– The MSRA procedure combines the method statement and risk assessment into one document, designed to ensure that the subcontractor meets his HSE responsibilities in the workplace, and is based on the general principles of risk prevention, as follows:

i. **Plan the works**
– Break down the task and arrange steps in proper method.

ii. **Identify Hazards**
– Identify Hazards and subsequent Risks

iii. **Risk Assessment**
– Analyze and control the Risks when they cannot be eliminated or avoided

iv. **Procedure**
– Use work methods and equipment adapted to task and the Risk
– Collective protection has priority over individual protection
– Consider technical evolutions of the work
– Plan prevention
– Review regularly and update when necessary

v. **Prepare the Team**
– Inform and train employees about the Risks and the control measures (task specific instruction)

vi. **Execute**
– Record findings and control measures

2.2 Risk/Impact Assessment Process

2.2.1 Hazard Identification

i. This step is the basis of all Risk Assessment. Five key elements are to be considered to systematically identify all the significant hazards that exist in work activities: People, Equipment, Procedure, Work place (work environment) and Materials.
ii. After the consideration of the above five key elements, the inventory of hazards should be reviewed by following criteria: -
– Determine what hazards have been identified.
– Arrange hazards in priority of assessment.
iii. As per the project scope of works and assessment of the project activities the following had been resulted as major HSE hazards / Impacts during the construction phase:
– Working at heights and falling from heights;
– Drop and falling objects;
– Slip and trip hazards;
– Working in confined spaces;
– Radiations (Ionizing and Non-Ionizing);
– Electrical shock and burns;
– High pressure; Liquid, Gas;
– Heat Stress (Weather conditions, During Hot works and Operations);
– Espouser to Noise (Occupational);
– Poor Air Quality due to emissions (Dust, O_2, SO_x, NO_x, H_2S, etc.);

- Flying particles and objects;
- Exposure to Hazardous substances;
- Striking against / struck by object;
- Manual handling of good and Tools; back injuries and Musculoskeletal disorders;
- Animal / Insect Pits;
- Transport / Vehicle;
- Fire and Explosive atmosphere;
- Exposure Biological agent

2.2.1.1 Hazard Effect

- The possible effect of identified hazards shall be depending on the location, surroundings and type of hazard.

2.2.1.2 Who and How People Might be at Risk

i. The wide implications of hazards shall be taken in consideration. Exposed people classification can be estimated according to: -
   - **Direct effect**: - People who be affected in the immediate environment.
   - **Indirect effect**: - Other staff groups, such as maintenance personnel and cleaners, as well as visitors and public
ii. Special attention should be paid to inexperienced staff, lone workers or temporary staff and to the particular needs of disabled staff, pregnant women and children.

2.2.1.3 Identify the Existing Control Measures, if any

i. The basic principle of controlling Risk in the work place is to either remove the Risk or to Control its possible impact.
ii. If it is not reasonably practicable to implement the first measure, the next level should be tried, with the least favoured option being the provision of personal protective equipment.
iii. If complete protection is not afforded by one option it is reasonably practicable to introduce it, then a combination of measures is the most effective way to adequately control the risk.
iv. Contractor and its subcontractors shall ensure that the effective control measures remain in place and then any change could be applied in workplace conditions, Add or modify to control measures is highly required.

2.2.1.4 Environmental Impact assessment

i. Contractor and it subcontractors shall identify the environmental aspects of its activities to determine the environmental significant impact(s) on the environment.
ii. The same methodology of safety risk assessment will be followed by the contractor and its subcontractors to identify, assess and control the environmental impacts.
iii. The Activity MSRA shall include all environmental aspects and control.
iv. The environmental impact mitigation plan shall be complying with the Project Environmental Impact assessment.
v. The environmental Impact and risks matrix developed as per the project ESIA findings and it will include but not limited to the following impacts:
   - Dust Emission;
   - Gaseous Emission;
   - Noise;
   - Sewage Generation;
   - Waste Water;
   - Accidental Spillage of Fuel and Chemicals;
   - Land Contamination;
   - Traffic issues; and
   - Community Complaint.

2.2.2 Risk Evaluation

– In order to prioritize the level of Risk associated with identified Hazards, the Risks will be evaluated in accordance with their probability and severity, and classified in the categories indicated below:

Probability (P) (of harm occurring)	Very low	– Close to zero probability
	Low	– Unlikely but conceivable
	Medium	– May occur, – Could well occur
	High	– May occur several times, – Not surprising, – Occurs frequently, – To be expected

Severity (S) (of probable harm)	Light	– Minor injuries such as small cuts and bruise.
	Medium	– Injury with short term effect, not reportable.
	Severe	– Major injury or disability – Ill health with long- term effect reportable; – Single fatality
	Extreme	– Multiple fatalities, – disasters

Severity / Probability	Light	Medium	Severe	Extreme
Very low	–	–	D	C
Low	–	D	C	B
Medium	D	C	B	A
High	D	B	A	A

2.2.2.1 Risk Rating and categories

Score	Risk Description	Color-code
B-A	High Risk	3
D-C	Medium Risk	2
--	Acceptable Risk	1

Risk is acceptable:

– If the risk is determined to be acceptable;
– There is no need to take action;

– General safety regulations and standard PPE reasonably control the risk.

2.2.3 Risk controls

– The hazard must be reduced to an acceptable residual risk level by defining suitable measures.
– As a rule, the measure with the largest coverage should be chosen. If necessary, measures must be combined. The measures must be assigned in accordance with the hierarchy specified by the "TOP process" (technical, organizational, personal).

2.2.3.1 Technical

– Shielding of hazardous areas (physical barriers such as enclosures, access restrictions, fire zones)
– Technical safety systems (e.g. emergency-OFF, fault current protection switch)
– Technical aids (e.g. lift aids)
– Ventilation, exhaust.

2.2.3.2 Organizational

– Substitution of hazardous substances, equipment and activities
– Inspection of systems, equipment and facilities
– Written approval procedures for certain activities
– Briefings and instructions
– Special training
– Medical check-up and health surveillance
– Measurements of hazardous materials
– Safety data sheets
– Safety markers and labels in the workplace

2.2.3.3 Personal

– Reliability and safety awareness
– Personal protective equipment (PPE)

2.2.3.4 After implementation of control measures, the Risk Level should be reduced to an acceptable risk. If this is not the case, the foreseen measures for controlling the Risk must be clearly described.

2.2.4 Residual Risk Evaluation

– The remaning residual risk is assessed to estimate the effectiveness of measures.

Assessment of residual risk	
The accepted residual risk for this hazard is achieved through multiple measures. (This measure is not sufficient to achieve an acceptable residual risk for this hazard except in combination with other measures.)	3
The accepted residual risk for this hazard is partly achieved through this measure. (This countermeasure goes some way toward achieving an acceptable remaining risk for this hazard.)	2
The accepted residual risk for this hazard is achieved through this measure. (This countermeasure achieves an acceptable remaining risk for this hazard.)	1

3.0 REQUIREMENT FOR MSRA

1. For works including one or more of the following hazards or risk categories, MSRA's are required:

– Working at height with a fall hazard, esp. working with safety harness
– Complex lifting activities (dimension of load, weight, tandem lifts etc.)

- Hit by flying or falling objects
- Use of heavy machinery
- Working above or under water levels
- Drowning or asphyxiation
- Contact with harmful substances or energy
- Co-activity with direct interferences to other Contractors

ii. Additionally, the subcontractor may at any time be required by the Contractor to provide an MSRA for any given task.

iii. Generally, the subcontractor shall be required to provide a MSRA in the following circumstances:

- The task is not sufficiently described in the subcontractor's HSE Management Plan.
- The task is not sufficiently described in a PTW application.
- The task is additional to the scope of the Works.
- The methods or circumstances for executing the task have changed.
- The conditions on Site are such that the task could pose additional/subsequent risks to the site personnel, the environment or site installations.

4.0 PREPARATION OF MSRA

- The M/RA document shall be completed in the following manner:

i. Complete sections 1, 2, 3 of Method Statement Form (Attachment 01):

- Section 1 – Description of the work
- Section 2 – Sequence of tasks: this is a clear description of each of the main tasks in chronological order explaining how they will be executed
- Section 3 – Operational details

ii. Complete the Risk Assessment Form (Attachment 02):

- Identify and note all of the hazards and subsequent risks, in relation to the sequence of tasks and operation details in the "Hazard and subsequent risk" column. The list of Hazards, Risks and environmental impacts mentioned here (section 2.2.1 Hazard Identification) will assist in identifying potential hazards and subsequent risks.
- Assess the identified risks to establish whether or not control measures are required; this is recorded in the "Assessment – no controls" column – use the "Method of Risk Classification" mentioned here (Section 2.2.2 Risk Evaluation).
- If control measures are required, determine what those control measures should be and record those in the "Controls" column. Note: more than one control measure may be required.
- Re-assess the risks in the "Assessment – with controls" column to establish whether or not sufficient control measures have been adopted. Re-evaluate the control measures if necessary until the risk of harm has been effectively managed.
- Join the Method Statement form and the Risk Assessment form together.
- Attach any additional documents, plans, drawings, SDS, etc. to the MSRA as required.
- Complete section 5 – sign, date and submit the MSRA (see **Section 5.0)** to the Site Management for review and comment.
- The subcontractor shall be responsible for any delays where any revision or amendment of the MSRA is required.
- Once the MSRA has been accepted, the applicant must ensure that all personnel involved in the execution of the work are fully informed of the risks and the control measures via a formal Tool-Box-Talk attended by all personnel prior to the commencement of work. An attendance record form for this purpose is supplied with the MSRA.

5.0 SUBMISSION AND REVIEW OF MSRA

- All MSRA shall be submitted to the Contractor for review and comment a minimum of (two) weeks before scheduled commencement of the works, as follows:

i. Submit MSRA documents officially to the Contractor.

ii. The Contractor will review the technical and safety aspects of the MSRA and will, if necessary, make comment on a cover sheet (Attach 03) and/or in the MSRA document.

Comments of Category "A" are mandatory to be fully implemented/followed during execution of the works. Comments of Category "B" require a revision of the MSRA and resubmission for approval.

iii. The Contractor may at any time require the subcontractor to review or revise a MSRA during the construction or erection works for which it has been established. If this becomes necessary, the revised MSRA must be submitted to the Contractor for review and comment within a reasonable timeframe (approximately 1 week prior to start of works) thereafter. The Contractor reserve the right to suspend construction or erection activities until any MSRA revision process has been completed.

iv. For auditing purposes, the subcontractor shall retain copies of all MSRA documents relevant to their work on file for the duration of the Project.

6.0 ATTACHMENTS

6.1 Att.01: - Method Statement Form

6.2 Att.02: - Risk Assessment Form

6.3 Att.03: - MSRA Cover Page

6.4 Att.04: - MSRA Log

METHOD STATEMENT FORM

Cost Center Name : _____ Cost Center No. : _____ MS No. : _____

Procedure:

Complete sections 1,2,3 – Method Statement	☐
Complete Risk Assessment – SI003 Att.02	☐
Attach any additional documents and drawing as necessary	☐
Complete section 5- Sign and submit to Site Management Review	☐

1- Description of Work:

☐ Civil ☐ Electrical ☐ Mechanical ☐ Other (*Please specify*)

Location of Work: _____ Start Date: _____

End Date: _____

Brief Description of Work:

2- Sequence of Tasks: (attached additional sheets if required)

1.	
2.	
3.	
4.	

3- Operational details:

Permit To Work :

☐ Yes

☐ No

If yes *please specify* .....

Activity Type and Special Needs:

☐ Work at heights
☐ Confined Space
☐ Manual Lifting
☐ Crane Operation
☐ Excavator
☐ Plant/Equipment
☐ Other Machines *(Please Specify)*
☐ Electrical Tools
☐ Electrical Installations
☐ Welding Equipment
☐ Gas/Gas Cylinders
☐ Chemicals
☐ Dangerous Goods
☐ Heavy Transport
☐ Road Block
☐ Special PPE: *Please specify* .....
☐ Co-activity: *Please specify* .....
☐ Others: *Please specify* .....

Using of Hazardous substances

☐ Yes ☐ No *If yes please give the following details:*

Material Safety Data Sheet available *(To be attached with MSRA)* Yes ☐ No ☐

Any special handling procedures available *(To be attached with MSRA)* Yes ☐ No ☐

Temporary Services Required:

Electricity	Yes ☐	No ☐	*If yes how* .....
Lighting	Yes ☐	No ☐	*If yes how* .....
Water	Yes ☐	No ☐	*If yes how* .....
Other	Yes ☐	No ☐	*If yes how* .....

Man-Power

Supervisor	☐	Machine operator	☐
Skilled Person	☐	First Aider	☐
Unskilled person / Temporary worker	☐	HSE	☐

4- Complete the Risk Assessment Form:

Att. 02 the Risk Assessment form by developing all of points mentioned in the section 2, 3 above. Attach plans and drawing as required.

Number of Risk Assessment pages: ☐

List of Attachments:

1. ..... 4. .....
2. ..... 5. .....
3. ..... 6. .....

5- Applicant responsibility

The Applicant is responsible to ensure that all of the conditions as stated in this MSRA are implemented and that the full content of the MSRA is transferred to and clearly understood by all personnel involved via a signed tool-box-talk prior to the commencement of the work. A copy of the MSRA must be available at the work area at all times for reference and review.

Applicant

Name	Position	Signature	Date

RISK ASSESSMENT FORM

Cost Center Name : _____ Cost Center No. : _____ RA No. : _____

Risk Assessment for Method Statement No. : _____ Contractor Name : _____ Revision No. : _____

Method Statement Title : _____ Date : _____

Probability (P)	**Severity (S)**
1 = Very Low	1 = Light
2 = Low	2 = Medium
3 = Medium	3 = Severe
4 = High	4 = Extreme

Risk level (R)

P/S	S1	S2	S3	S4
P1	-	-	D	C
P2	-	D	C	B
P3	D	C	B	A
P4	D	B	A	A

B - A = Risk reduction urgently necessary
D - C = Risk needs to be reduced
-- = Risk is acceptable

Ser.	Task/Activity / Operation	Hazard	Hazard Effect	Assessment No Control			Control Measures	Assessment With Control		
				P	S	R		P	S	R
01							–			
02							–			
03							–			
04							–			
05							–			
06							–			
07							–			
08							–			
09							–			
10							–			

RISK ASSESSMENT FORM

Ser.	Task/Activity / Operation	Hazard	Hazard Effect	Assessment No Control			Control Measures	Assessment With Control		
				P	S	R		P	S	R
11							–			
12							–			
13							–			
14							–			
15							–			

Summary of Requirements:

1 Specific Training :
2 PPE :
3 PTW required :
4 Supervision Level :
5 Emergency Preparedness :
6 HSE Measurements :
7 Isolation Requirements :
8 Certificates, SDS or Data Sheets :

Assessed by:

Name	Position	Signature	Date

METHOD STATEMENT / RISK ASSESSMENT

submitted by

Company	Date

KKS	MS #
	Contractor-Rev.

Start of works	
Date	

Risk Assessment	
Yes	No

Pages

MSRA title and purpose

Reviewed	Name	Signature	Date	Comments
Civil				
M				
E				
Comm				
HSE				

Comments (Contractor)

☐ **The submission has been accepted.**
The work covered by the MSRA is released to commence in accordance with the MSRA. All personnel involved have to be briefed in line with the content of the MSRA and sign on to it. Work Permits have to be obtained as applicable. Changes in the work method require a resubmission.

☐ **Please take note of the comments made and implement appropriately. The submission has been accepted.**
The work covered by the MSRA is released to commence in accordance with the MSRA including comments. All personnel involved have to be briefed in line with the content of the Method Statement and sign on to it. Work Permits have to be obtained as applicable. Changes in the work method require a resubmission.

☐ **The submission has NOT been accepted.**
Comments have to be implemented and the MS/RA to be resubmitted for acceptance prior start of the work.

Technical

HSE

Release (Contractor)	

COMMENTS: **A** - attention **B** - revision

Note: Only valid in conjunction with Project and Contractor HSE Manuals. Acceptance of the MSRA by the Contractor and the contractor comments do not

Method Statement and Risk Assessment Log

MSRA No.	Location / Unit	Method Statement & Risk Assessment Title	Activity Type	Issuing Date	Rev. No	Status	Prepared by	Reviewed by
#0001								
#0002								
#0003								

ATTACHMENT # 09
CONSTRUCTION SCHEDULE OF DIVERSION TUNNEL

#	Activity ID	Activity Name	Original Duration	Start	Finish
1		**SCHEDULE FOR DIVERSION TUNNEL CONSTRUCTIO**	378	2019-06-19 A	2020-06-30
2		**Milestones**	378	2019-06-19 A	2020-06-30
3		**Adit Tunnel**	104	2019-06-20 A	2019-08-28 A
4	DTAT1.100	Portal Excavation & Support	35	2019-06-20 A	2019-07-24 A
5	DTAT1.110	Excavation from Ch. 0+000.00~0+020.00; 20m	16	2019-07-25 A	2019-08-09 A
6	DTAT1.120	Excavation from Ch. 0+020.00~0+144.00; 124m	53	2019-08-10 A	2019-08-28 A
7		**Inlet Portal**	377	2019-06-20 A	2020-06-30
8	DTIP1.000	Coffer Dam Construction	42	2019-09-26	2019-11-06*
9	DTIP1.360	Formworks Removal & Clearance	7	2020-06-24	2020-06-30
10		**Excavation & Support**	226	2019-06-20 A	2020-01-31
11	DTIP1.100	Excavation and support El. ~139.00	30	2019-06-20 A	2019-07-19 A
12	DTIP1.110	Excavation and support El. 139.00~119.00	20	2019-07-20 A	2019-08-08 A
13	DTIP1.120	Excavation and support El. 119.00~104.00	16	2019-08-09 A	2019-08-24 A
14	DTIP1.130	Excavation and support El. 104.00~92.00	12	2019-08-25 A	2019-09-05 A
15	DTIP1.140	Excavation and support El. 92.00~80.00	12	2019-09-06 A	2019-09-11 A
16	DTIP1.150	Excavation and support El. 80.00~64.50	14	2020-01-18	2020-01-31
17		**Diversion Tower**	144	2020-02-01	2020-06-23
18	DTIP1.160	Bottom Slab Concrete (El. 65.50~67.00)	10	2020-02-01	2020-02-10
19	DTIP1.170	Bottom Slab Concrete (El. 67.00~68.50)	7	2020-02-11	2020-02-17
20	DTIP1.180	Pier Concrete (El. 68.50~71.50)	7	2020-02-18	2020-02-24
21	DTIP1.190	Pier Concrete (El. 71.50~74.50)	7	2020-02-25	2020-03-02
22	DTIP1.200	Pier Concrete (El. 74.50~77.50)	7	2020-03-03	2020-03-09
23	DTIP1.210	Pier Concrete (El. 77.50~80.50)	7	2020-03-10	2020-03-16
24	DTIP1.220	Pier Concrete (El. 80.50~83.50)	7	2020-03-17	2020-03-23
25	DTIP1.230	Top Slab Concrete (El. 83.50~86.50)	10	2020-03-24	2020-04-02
26	DTIP1.240	Top Slab Concrete (El. 86.50~89.50)	7	2020-04-03	2020-04-09
27	DTIP1.250	Top Slab Concrete (El. 89.50~92.50)	7	2020-04-10	2020-04-16
28	DTIP1.260	Tower Concrete (El. 92.50~95.50)	7	2020-04-17	2020-04-23
29	DTIP1.270	Tower Concrete (El. 95.50~98.50)	7	2020-04-24	2020-04-30
30	DTIP1.280	Tower Concrete (El. 98.50~101.50)	7	2020-05-01	2020-05-07
31	DTIP1.290	Tower Concrete (El. 101.50~104.50)	7	2020-05-08	2020-05-14
32	DTIP1.300	Tower Concrete (El. 104.50~107.50)	7	2020-05-15	2020-05-21
33	DTIP1.310	Tower Concrete (El. 107.50~110.50)	7	2020-05-22	2020-05-28
34	DTIP1.320	Tower Concrete (El. 110.50~113.50)	7	2020-05-29	2020-06-04
35	DTIP1.330	Tower Concrete (El. 113.50~116.00)	7	2020-06-05	2020-06-11
36	DTIP1.340	Tower Concrete (El. 116.00118.00)	10	2020-06-12	2020-06-21
37	DTIP1.350	2nd Stage Concrete	60	2020-04-25	2020-06-23
38		**HM Works**	35	2020-04-24	2020-05-28
39	DTIP0.0	Installation of Bottom Embedded Parts	5	2020-04-24	2020-04-28
40	DTIP0.000	Installation of Embedded Parts 1st Bay	15	2020-04-29	2020-05-13
41	DTIP0.10	Installation of Embedded Parts 2nd Bay	15	2020-05-14	2020-05-28
42		**Outlet Portal**	358	2019-06-20 A	2020-06-11
43	DTOP0.000	Construction of Coffer Dam	42	2019-09-29	2019-11-09*
44	DTOP0.101	Outlet Channel Concreting	90	2020-03-14	2020-06-11
45		**Excavation & Support**	268	2019-06-20 A	2020-03-13
46	DTOP1.100	Excavation and support El. ~140.00	30	2019-06-20 A	2019-07-19 A
47	DTOP1.110	Excavation and support El. 140.00~120.00	24	2019-07-20 A	2019-08-12 A
48	DTOP1.120	Excavation and support El. 120.00~105.00	16	2019-08-13 A	2019-08-28 A
49	DTOP1.130	Excavation and support El. 105.00~85.00	15	2019-08-29 A	2019-09-12 A



Remaining Level of Effort | Actual Work | Critical Remaining ...
Actual Level of Effort | Remaining Work | Milestone

TASK filter: All Activities

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SCHEDULE FOR DIVERSION TUNNEL CONSTRUCTION | DETIAL CONSTRUCTION PLAN | 2019-09-20

#	Activity ID	Activity Name	Original Duration	Start	Finish
50	DTOP1.140	Excavation and support El. 85.00~73.00	10	2019-09-12	2019-09-21
51	DTOP1.150	Excavation and support El. 73.00~60.20	21	2020-02-22	2020-03-13
52	**Main Tunnel**		293	2019-08-29 A	2020-06-30
53	DTMT0.000	Grouting & Finalization	85	2020-04-07	2020-06-30
54	**Excavation & Support**		163	2019-08-29 A	2020-02-21
55	DTMT1.121	Platfrom 1 transport & installation (for Adit to d/s face)	7	2019-09-12	2019-09-18
56	DTMT1.123	Platform 2 transport & installation (for Adit to u/s face)	7	2019-09-26	2019-10-02
57	DTMT1.133	Platfrom 3 transport & installation (for Inlet face)	3	2019-09-12	2019-09-14
58	DTMT1.270	Platfrom 4 transport & installation (for Outlet face)	5	2019-09-22	2019-09-26
59	**From Adit**		157	2019-08-29 A	2020-02-15
60	**Stage 1 (by Adit Platform)**		26	2019-08-29 A	2019-09-25
61	DTMT1	From Adit to u/s: Ch.0+333.00~0+295.80 (Upper portion)	14	2019-08-29 A	2019-09-11 A
62	DTMT1	From Adit to d/s: Ch.0+333.00~0+400.00.00 (Upper portion)	26	2019-08-31 A	2019-09-25
63	**Stage 2 (by new Platform)**		150	2019-09-19	2020-02-15
64	DTMT1	Remaining Excavation & support of Junction (Wall & Top)	12	2019-09-19	2019-09-30
65	DTMT1	From Adit to u/s: Ch.0+295.80~0+170.00 (Upper portion)	56	2019-10-03	2019-11-27
66	DTMT1	From Adit to u/s: Ch.0+333.00~0+130.00 (Middle portion)	45	2019-12-08	2020-01-21
67	DTMT1	From Adit to u/s: Ch.0+333.00~0+130.00 (Bottom portion)	25	2020-01-22	2020-02-15
68	DTMT1	From Adit to d/s: Ch.0+400.00~0+543.00.00 (Upper portion)	75	2019-10-01	2019-12-14
69	DTMT1	From Adit to d/s: Ch.0+333.00~0+473.00.00 (Middle portion	28	2019-12-15	2020-01-11
70	DTMT1	From Adit to d/s: Ch.0+333.00~0+473.00.00 (Bottom portio	14	2020-01-12	2020-01-25
71	**from Inlet Portal (by new Platform)**		125	2019-09-15	2020-01-17
72	DTMT1.1(	Ch.0+000.00~0+170.00 (Upper portion)	84	2019-09-15	2019-12-07
73	DTMT1.1	Ch.0+000.00~0+130.00 (Middle portion)	26	2019-12-10	2020-01-04
74	DTMT1.1	Ch.0+000.00~0+130.00 (Bottom portion)	13	2020-01-05	2020-01-17
75	**from Outlet Portal (by new Platform)**		148	2019-09-27	2020-02-21
76	DTMT1.1(	Ch.0+703.00~0+543.00.00 (Upper portion)	69	2019-09-27	2019-12-04
77	DTMT1.1	Ch.0+703.00~0+473.00.00 (Lower portion)	46	2019-12-15	2020-01-29
78	DTMT1.1	Ch.0+703.00~0+473.00.00 (Bottom portion)	23	2020-01-30	2020-02-21
79	**Transition Section**		135	2020-02-01	2020-06-14
80	DTMT1.180	Ch. 0+000.00~0+021.00 (Slab)	20	2020-02-01	2020-02-20
81	DTMT1.190	Ch. 0+000.00~0+021.00 (Side Wall)	20	2020-02-21	2020-03-11
82	DTMT1.200	Ch. 0+000.00~0+021.00 (Top Crown)	20	2020-03-12	2020-03-31
83	DTMT1.210	Ch. 0+021.00~0+035.00 (Slab)	20	2020-04-01	2020-04-20
84	DTMT1.220	Ch. 0+021.00~0+035.00 (Side Wall)	20	2020-04-21	2020-05-10
85	DTMT1.230	Ch. 0+021.00~0+035.00 (Top Crown)	35	2020-05-11	2020-06-14
86	DTMT1.240	Ch. 0+035.00~0+050.00 (Slab)	20	2020-02-01	2020-02-20
87	DTMT1.250	Ch. 0+035.00~0+050.00 (Side Wall)	20	2020-02-21	2020-03-11
88	DTMT1.260	Ch. 0+035.00~0+050.00 (Top Crown)	35	2020-03-12	2020-04-15
89	**Concrete Lining u/s to Adit**		152	2020-01-18	2020-06-17
90	DTMT2.100	Assembly of Formwork	30	2020-01-18	2020-02-16
91	DTMT2.110	Concrete Lining Ch. 0.050.00~374.00	96	2020-02-22	2020-05-27
92	DTMT2.120	Dismantle and Removal of Formwork	21	2020-05-28	2020-06-17
93	**Concrete Lining Adit to d/s**		147	2020-01-26	2020-06-20
94	DTMT2.130	Assembly of Formwork	30	2020-01-26	2020-02-24
95	DTMT2.140	Concrete Lining Ch. 0+371.00~0+703.00	96	2020-02-25	2020-05-30
96	DTMT2.150	Dismantle and Removal of Formwork	21	2020-05-31	2020-06-20



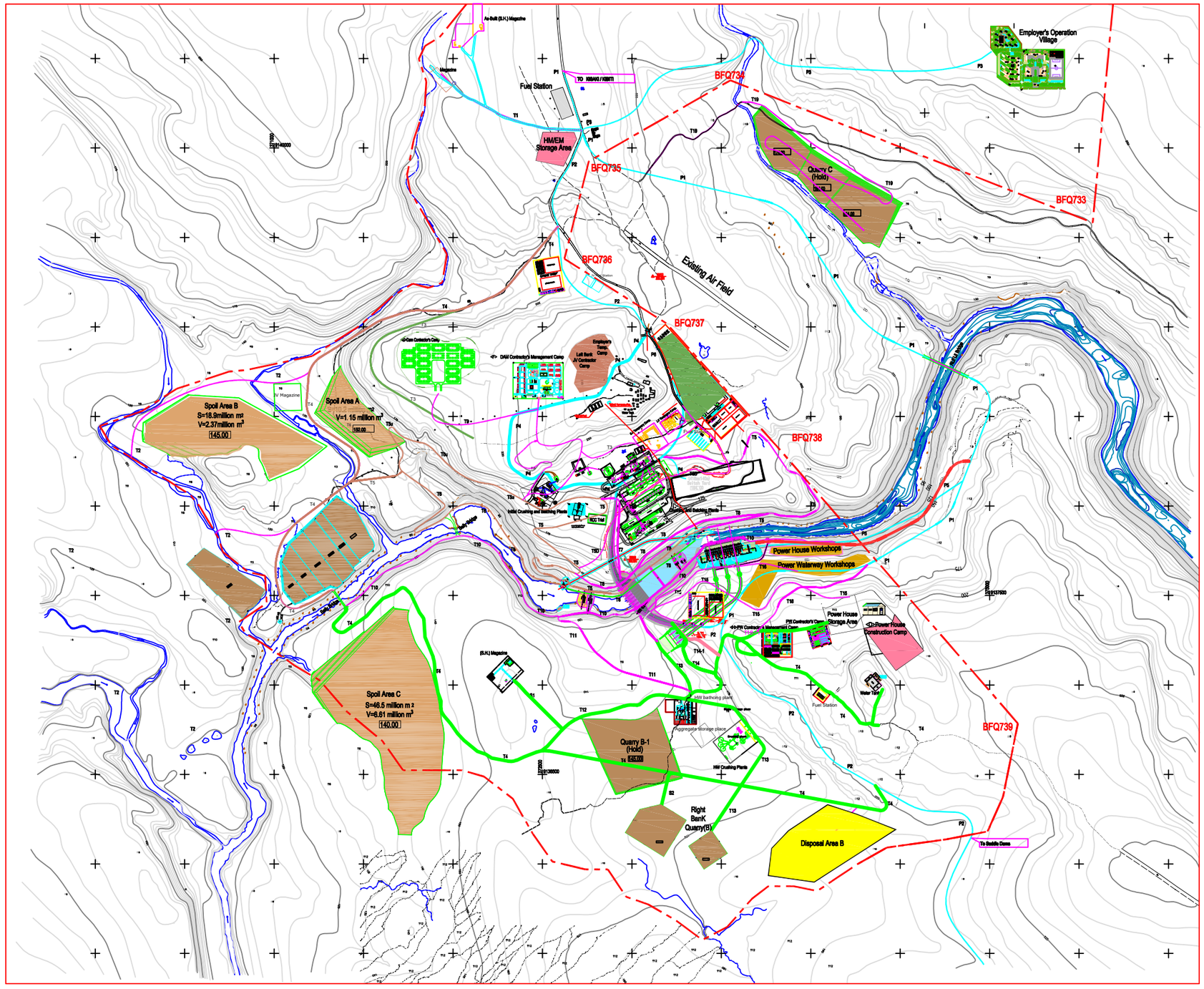
Remaining Level of Effort | Actual Work | Critical Remaining ... | Milestone
Actual Level of Effort | Remaining Work

TASK filter: All Activities

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Attachment # 10
CONSTRUCTION GENERAL LAYOUT

SUBSIDIARY FACILITIES LAYOUT OF RUFIJI HYDROPOWER PROJECT



Legends

- Boundary Line
- Temporary Roads
- Permanent Roads
- Bridge
- Magazine
- Camp/Office
- Construction Facility
- Transformer for Construction

SCALE A

0 100 200 300 400 500m

Note:

The construction general layout is planned base on the preliminary site surveying and investigation, and it shall be modified and/or relocated as per the client's requirement and detailed site surveying and investigation.

Sub Contractor: SINOHYDRO CORPORATION LIMITED		PROJECT: Construction of Rufiji Hydropower Project at Stiegler's Gorge along the Rufiji River	
APPROVED		TITLE: SUBSIDIARY FACILITIES LAYOUT OF RUFIJI HYDROPOWER PROJECT	
CHECKED			
DESIGNED		SCALE:	REV: A
		DRAWING No.: PHP-LJ-05	